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THE MOURNE MOUNTAINS.

By GRENVILLE A. J. COLE, M.R.I.A., F.G.S., *Professor of Geology in the Royal College of Science for Ireland.*

IT is one of the many advantages of a thinly populated country that its barren regions are left very much to lovers of scenery. The Mourne Mountains, though situated on the easily accessible coast of the county of Down, have remained but little visited, even by dwellers in Ireland. Despite the admirable introductions that have been made to them in recent years,* the scientific observer and the keen pedestrian need have little fear of being hampered in their pursuits by the presence of the purely casual tourist.

Those, however, who may not find it convenient to leave the beaten track, can, in a few inspiring drives, complete the circuit of the Mournes, and can even cross at one point from the western meadows to the sea. The character of the mountain group, in all its isolated individuality, can, indeed, be best grasped from a preliminary survey of its spurs. From Newry, at the head of the long Carlingford inlet, we climb to the upland formed by the "Caledonian" granite in this district, and presently, across the Silurian foot-hills, we see upon our right the grey-green ridges of the Mournes. At Hilltown we meet the first road that cuts into the silent area, and we gain some notion of the steep-sided valleys that lie between these smooth round domes. On certain of the nearer summits, little "tors" of rock stand out, much as they do on Dartmoor, but on a more impressive scale. Then, as we follow the steadily rising road, we are cut off for a time from distant views; but in four miles the finest of them all bursts on us—the seemingly sheer face of Slieve Meel, the grass, as it were, sliding away on it and leaving the bare white rock exposed; and beyond, across a romantic bend of the valley, the craggy *arête* of Slieve Bernagh—without question the noblest summit of the Mournes.

And so down, mile after mile, under the wooded slopes to Bryansford, where the corner is turned and we see the northern aspect of the highland. Slieve Commedagh and Slieve Donard, with a rocky pass between them, dominate the landscape here, the latter being the highest mountain of them all. Its two thousand seven hundred and ninety-six feet bring it, in fact, only a little short of Cader Idris.

On the east, this compactly arranged highland falls steeply to the sea, so that the summit of Slieve Donard is only two miles from the actual coast. The splendid road is carried, as best it may be, between the heather of the moorland and the sea, and crosses at intervals the alluvial fans that stream down from the eastern valleys. A pebbly raised beach that runs along part of the coast also provides a convenient terrace.

At Bloody Bridge, only two miles south of Newcastle, the old roadway, of bitter memory, is seen a little further up the glen; and behind it, and stretching high towards the notch from which the stream descends, is one of those huge cones of detritus that assure one of the reality of denudation. It may have been formed, in the first instance, by a landslide; but it no doubt was freely added to when the mountains above were at their highest. Now the stream has cut a clear section through it, down to the granite floor, and grass has climbed across the slopes of Slieve Donard, from which much of the material fell. The outer edge of the cone has, moreover, been removed by the sea; but in its remaining mass, and the beauty of its form, it is still an admirable picture of a talus-fan, such as may be seen in full vitality at the foot of any ravine in Norway, Tyrol, or Karinthia.

At the tiny port of Annalong, we cross one of the larger rivers of the Mournes, which rises in a superb steep-sided valley under the rock-terraces of Slieve Commedagh. A second large stream, the waters of which are about to be stored up for Belfast, comes down out of a similar valley at Kilkeel; and soon the road turns westward, passes along the beautiful sea-inlet up to Rostrevor, Warrenpoint, and Narrow Water, and reaches Newry, where the fifty-mile circuit is complete.

When we examine this mountain-mass in detail, we find that we are not dealing with a range, but with a great boss of granite, shaped somewhat like a dumbbell, the narrow part being crossed by the road from Hilltown to Kilkeel. The principal valleys have been cut far back from north or south. The watershed is consequently sinuous, between the short streams flowing to the Irish Sea and the rivers that reach the Atlantic with the Bann;

* R. Lloyd Praeger, M.R.I.A., "The Mourne Mountains," *Science Gossip*, new series, Vol. II. (1895), p. 85; and "Guide to County Down and the Mourne Mountains," published by the Belfast and County Down Railway Company, 1898, with one hundred illustrations, price 1s. (Marcus Ward & Co.)

XUM

but it has, when mapped out, a fairly north-east and south-west trend. A bold line of summits lies along it, from Slieve Meel More to Eagle Mountain; but their average elevation is surpassed by those rising from the wall between the Annalong and Kilkeel valleys, beginning with Slieve Commedagh (2512 feet), and ending in the castellated crags of Slieve Bingian (2449 feet), from which a long spur descends southward on Kilkeel. The depth of the valleys, in proportion to their width, is one of the fine features of the Mournes, and is only fully realised by walking along the watershed, and looking down over granite cliffs into these veritable grooves, the combes at their heads girt about with crags, and their mouths crossed by the blue horizon of the sea.

The north-and-south trend of the valleys is not due to any special structure of the Mournes, for it is one common to the district. So constant is it, whether the Mourne granite, or the Silurian strata, or the older granite of the Newry axis is traversed by the streams, that it probably points back to a time when the rocks exposed at the surface were more uniform in character, and when a highland of Silurian and Ordovician strata concealed the Mourne granite altogether. The watershed then may have run east and west, and on its surface the streams received a uniform trend. As they cut away this surface, particularly in the region of their head-waters, they came down upon the concealed granite boss, and worked against that more slowly. At one point, the streams running northward have found no granite as yet beneath them, and have notched back the old watershed conspicuously, forming the long valley leading over to Kilkeel.

According to this view, the domes and valleys of the Mourne Mountains have been carved out of an obstacle, discovered by the agents of denudation on the side of an older ridge. The former covering of Silurian strata is actually left to us in a few admirable outliers—a patch half a mile across on Thomas Mountain, about half way up Slieve Donard; another on Slievemaganmore, midway between Hilltown and Kilkeel, at a height of 1830 feet; and another, fifty feet higher, on Finlieve, some three miles to the south.* It has been stated that these flakes of strata have been floated up on the surface of the invading granite; but the Silurian beds

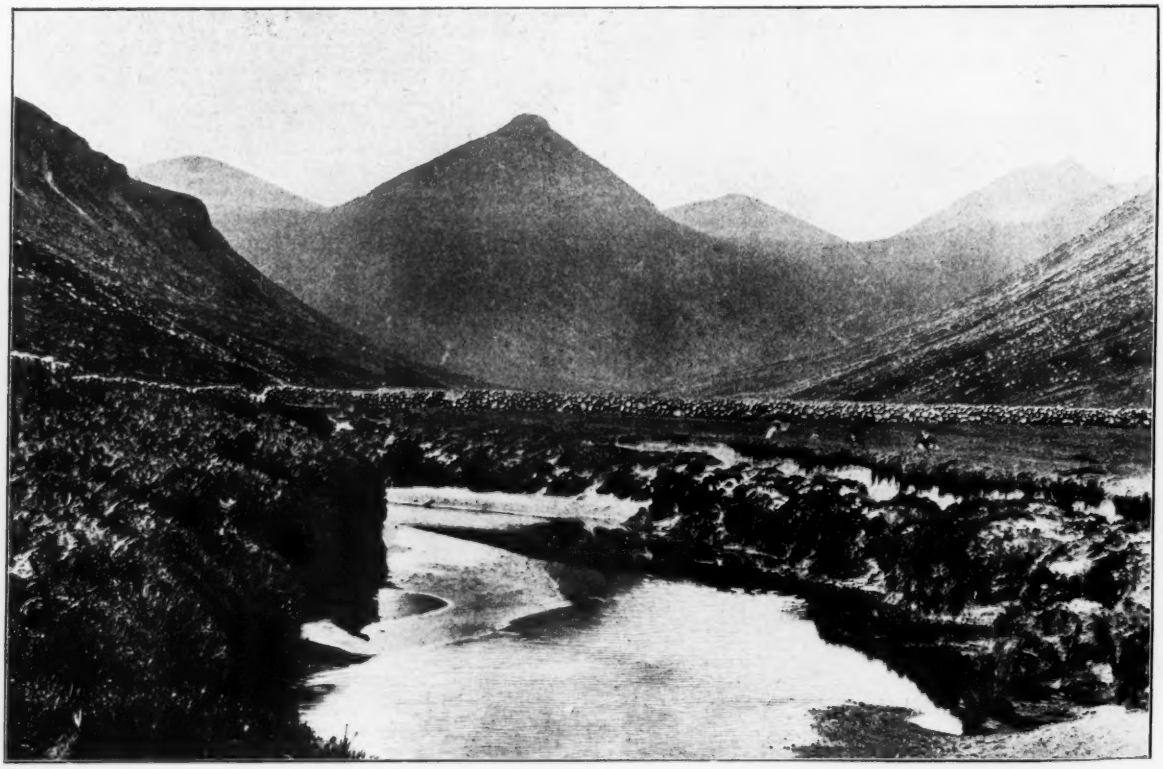


FIG. 1.—View in the Valley of the Kilkeel River, Mourne Mountains, showing cliff, taluses, and distant summits. The peak of Slieve Bernagh is on the right. [*R. Welch, Photo.*

in situ reach 1940 feet upon Slieve Muck, and 2200 feet on Shanslieve, north of Slieve Commedagh, and may thus easily, at no distant period, have covered the whole area of the Mournes.

Slieve Donard, in that case, would be one of the first knobs to protrude through the slates and sandstones as denudation had its way; while the low south-western portion of the granite has far more recently come to light. The boldness of outline, and the existence of so many contrasted domes and peaks (Fig. 1), point equally to the modern character of the group. Granite masses readily become worn down, in our climate, to round and uniform moorlands. On a fine day an observer on the Hill of Howth, near Dublin, has only to compare the outlines of the old Leinster granite with those of the blue peaks of

* The geological details are described in Traill, "Explanation to Sheets 60 and 71," *Geological Survey of Ireland* (1878), and Hull, "Explanation to Sheets 60, 61, and 71" (1881); but recent advances already necessitate some revision.

Mourne, some sixty miles north across the sea, to admit that the northern group has at least a supremacy of form.

This is apparent, also, in the details of the landscape, as one may come across them in the higher passes of the mountains. We have referred to the bold peak-like tors of Slieve Bernagh, and to the frequent vertical rock-walls; but the most impressive scene of all is, perhaps, the group of granite pinnacles weathered out on the south side of Slieve Commedagh. We may come upon these suddenly as the mist lifts from the great dome of Donard, leaving the deep valleys filled with cloud below us; and close against us is, as it were, a fantastic temple, the columns rising on each side of a little gorge. The vertical joints have here had a dominant effect, while the horizontal ones cut up the pinnacles with a fictitious air of masonry. The neighbouring cliffs also display the level tabular joints, so characteristic of granite, in a remarkable degree, and the whole hill-side suggests an acropolis given over to decay. The same air of titanic masonry is seen in the analogous granite mass of Goatfell in the Isle of Arran.*

This brings us to the petrological characters of the granite of the Mournes. While, as in the quarries that scar the hills near Annalong, the rock is often coarsely crystalline, the general mass is of finer texture, with a ground in which the quartz and the alkali-felspar may be intergrown with one another. The ferromagnesian constituent is a dark mica. Throughout the whole region a drusy structure is very common—that is, cavities occur, varying from a microscopic size up to four or five inches across, in which minerals have developed out freely, with all their proper forms (Fig. 2). The orthoclase felspar here appears in dull white or yellowish white crystals, as clean and neat as the wooden models that are placed before students of mineralogy. The quartz in these cavities is usually a smoky variety, forming prisms capped by pyramids, in complete contrast to its ordinary mode of occurrence in igneous rocks. The mica forms the most exquisite little hexagonal tables, standing up on edge; and, in addition, blue-green beryl and colourless topaz are not uncommon, and have been much sought for by collectors. One must conceive such a rock as having been saturated with liquids under pressure, each knot, if we may so say, of the liquid acting as a hydrothermal laboratory—at first delaying crystallisation, but finally allowing of free growth, and of the production of the most delicate prismatic forms. Few pleasures can be greater to the mineralogist than the breaking up of these granite blocks in the high passes of the Mournes, and the sight of the perfect little crystal-groups, lying there fresh as when made, and never before bared to human eye.

The granite of Arran, above referred to, is closely similar to that of the Mourne Mountains,† and we meet allied, but less drusy, masses in the heart of Mull and Skye. The latter rocks are among the more recent products of the great period of volcanic activity in the Hebrides, which opened in Lower Eocene times.‡ Hence the peculiar fine-grained granites of Mull and Skye are, at the earliest, of Eocene age.

South of Carlingford Lough there is another granite mass, which is intrusive in the dark gabbro of the Carlingford promontory. The relations of these rocks have been admirably described by Prof. Sollas;* and there is no doubt as to the correlation of the granite with that of the Mourne Mountains. The gabbro is represented on the Mourne coast by a multitude of dykes of basaltic andesite and basalt, which form a marvellous picture of the fracturing to which the Silurian rocks were subjected. These dark ribs of igneous rock have altered the Silurian shales and sandstones, which appear as a fringe along the coast; but they are cut off abruptly by the granite of the adjacent hills. The flakes of Silurian strata that remain here and there on the surface of the mountains are similarly seamed by dykes; but the granite cuts off all of them, and is clearly later than this first eruptive series. A few basic dykes, however, which may be well seen as grey-green bands in the granite north of Slieve Bernagh, cut through the granite, and represent a return of basaltic conditions. Hence we have three igneous series, two being basic, with a highly siliceous one between them.

This is precisely the order of events in the Eocene volcanic centres of Mull and Skye; and, even in microscopic details, the rocks of the one area may be paralleled by those of the other. Moreover, in the county of Antrim, the outpouring of the sheets of the "Lower Basalts" was followed by local eruptions of rhyolite, a highly siliceous lava, agreeing in composition with the granite of the Mournes.† This series was in turn buried by the "Upper Basalts." All this volcanic material in Antrim seems to be of Eocene age; and the sequence of events practically clinches the argument that the Mourne granite belongs also to the Eocene period.

FIG. 2.—Specimen of Mourne Granite, showing crystals developed in a drusy cavity. The pointer, marked T, indicates a crystal of topaz.

Here, then, we have a granite, one of those rocks formerly supposed to be of very ancient origin, brought near the surface as a fluid mass as recently as Cainozoic times, and probably not exposed, even in its upper layers, until shortly before the glacial epoch. The geological history of the Mournes, of Carlingford Mountain, and of the high volcano of Slieve Gullion in Armagh, is seemingly, then, a very modern matter compared with that of the adjacent Newry granite and the old weather-beaten core of Leinster.‡

Possibly the little dome of Ailsa Craig, which has suffered so heavily from denudation that its pebbles lie

* See the fine illustration in Sir A. Geikie's "Ancient Volcanoes of Great Britain," Vol. II., p. 419.

† See Judd, "Secondary Rocks of Scotland," *Quarterly Journal Geological Society*, Vol. XXX (1874), p. 275; and Teall, "British Petrography," pp. 328 and 330.

‡ See J. Starkie Gardner, "Lower Eocene Plant-Beds of Ulster," *Quarterly Journal Geological Society*, Vol. XLI. (1885), p. 82, and "Leaf-Beds of Ardtun," *ibid.*, Vol. XLIII., p. 292.

* "The Volcanic District of Carlingford and Slieve Gullion," *Trans. R. Irish Acad.*, Vol. XXX. (1894), p. 477.

† See A. McHenry, "Age of the Trachytic Rocks of Antrim," *Geol. Mag.*, 1895, p. 264; also G. Cole, "Rhyolites of County Antrim," *Sci. Trans. R. Dublin. Soc.*, Vol. VI. (1896), pp. 84 and 104.

‡ See KNOWLEDGE, Vol. XXI. (1898), p. 76.

scattered by hundreds all down the Irish coast, was a bold mass of the same age as the Mournes and Arran, and became almost destroyed by the severities of glacial times. In any case, we can now follow out the line along which granite intruded in Eocene times, from the south of Carlingford Lough to the smooth Red Hills of Skye. As yet denudation has discovered only the higher knobs, the fine-grained and the drusy surface-layers, of the great bar of crystalline rock that has here been added to the crust. Some day, perhaps, on the rising edge of Europe, the whole axis may become revealed, worn and rounded into one long moorland, extending north and south for two hundred and twenty miles.

Granites of Cainozoic age are naturally seldom met with, owing to the depth at which such rocks consolidate. It would be interesting to compare with the Mourne granite that described by M. Choffat from Cintra in the west of Portugal,* which penetrates Upper Jurassic strata, and which is probably of Eocene age. The granite of Elba is actually later than the Eocene; and, in the elevated regions of the Western Alps, which have been severely attacked by denudation, the central gneissic-granite may even belong to the Pliocene period.

We have already† pointed to the great north-and-south line, along which materials were erupted in Cainozoic times in Western Europe, as being possibly connected with the movements that determined our present continental edge. Certain it is that the signs of unrest spread eastward, and, by the close of the Miocene period, the central plateau of France, the brown-coal region of Bohemia, the fringe of the Hungarian plain, and the whole north-west of Italy, had already become involved. Then the great Alpine series of chains rose in their full vigour, and the volcanoes of Auvergne, Catalonia, the Eifel, and the eastern Rhinelands, piled up the cones that remain, scarcely denuded, at the present day. The Italian region, down to the sea between Sicily and Tunis, is still active and unstable; and, when compared with these vigorous manifestations, the land of Mourne assumes quite a cold and ancient aspect. The great lava-plateaux to the north of it were probably broken up and partly submerged by the forces that were raising Central Europe;‡ and the bold attempt at western elevation, which allowed of the ascent of the granite of the Mournes, seems to have ended merely in weakening the crust and in enlarging the bounds of the Atlantic.

THE PETROLEUM INDUSTRY.

By GEORGE T. HOLLOWAY, ASSOC. R.C.S. (LOND.), F.I.C.

ALTHOUGH the use of petroleum and its products, on what may be called a commercial scale, has only arisen within the last forty years, crude petroleum has been known and used from the earliest times. The "everlasting fire" of the Guebers, or fire worshippers of Baku, was fed by natural gas—really only the most volatile of the products of crude petroleum; but the most important of the early uses of this "rock oil" was for medicinal purposes—mainly skin diseases—for which purpose its value is even now recognized by the medical profession.

Numerous references to petroleum occur in the Scriptures, and, in the opinion of Lord Playfair, the "word translated as 'salt' in reference to its loss of savour on exposure, should have been rendered 'petroleum,' which, in the air, loses its more volatile constituents, and leaves asphalte, good only to be 'trodden under foot of men.'"

Petroleum appears to have been collected and sold at Baku, in Russia, and in the Burmese Empire earlier than in other districts; however, its exploitation on a large scale may be considered to date from the year 1859, when the celebrated "Colonel" Drake, acting on behalf of the Pennsylvania Rock Oil Company, sank the first well drilled avowedly in pursuit of oil, at Oil Creek in Pennsylvania. The hilarity which the public had previously indulged in immediately gave place to the "oil fever" when this well was found to yield to the pump twenty-five barrels of oil in a single day. Rapid development ensued down Oil Creek and along the Alleghany River, so that the output of two thousand barrels, each of forty-two American gallons, with which 1859 was credited, had risen to five hundred thousand barrels in 1860, and over two million barrels in 1861. Since then the yield has steadily increased, almost without any setback, until now the United States production amounts to over forty-seven million barrels.

The earlier wells yielded their oil only to the pump, but, in the summer of 1861, a well drilled to a depth of four hundred and sixty feet discharged its oil under pressure at the rate of three hundred barrels daily. This was followed by numerous other flowing or "spouting" wells, delivering, in some cases, as much as three thousand barrels daily, thus keenly accentuating the oil fever, which became so intense that the drilling of a successful well in a new district was the signal for a rush of prospectors, and, in case of further success, soon gave birth to a substantial town, which, when the oilfield became exhausted, might vanish as quickly as it had grown up.

A typical instance is found in Pithole City, which, about nine months after the discovery of oil, in January, 1865, had in its vicinity a population of between twelve and sixteen thousand, and, in importance, ranked but little below the flourishing town of Pittsburg. Within two years of its origin, however, its oil was practically all removed, and the founders deserted it in favour of numerous other fields which had meanwhile been developed.

In Russia the petroleum industry is of much greater antiquity than in the United States, and oil is said to have been exported from that country as early as the tenth century. The oil occurs in certain localities in much larger quantity than in the States, and is more cheaply produced; indeed, there is no doubt that the Russian industry will be flourishing when the American oilfields have been practically denuded of their contents, although, at present, the business ability, the enormous capital, and the perfect organization of the Americans, enable them to command the principal markets of the world.

The "spouting" wells of Russia entirely eclipse those of America in output. The first was struck in 1873 by the Kalify Company of Baku, and was followed by many others, the oil of most of them, as in the case of the American oil fountains, being wasted on account of lack of storage tanks to receive the sudden and enormous discharges. The most celebrated oil fountain known, although not the largest, was the "Droojba" well, which was struck on the 1st of September, 1883, and commenced flowing at the rate of about one million eight hundred thousand gallons daily, an amount of oil which was valued at eleven thousand pounds. The oil rushed from the well in a column about eighteen inches in diameter and nearly three

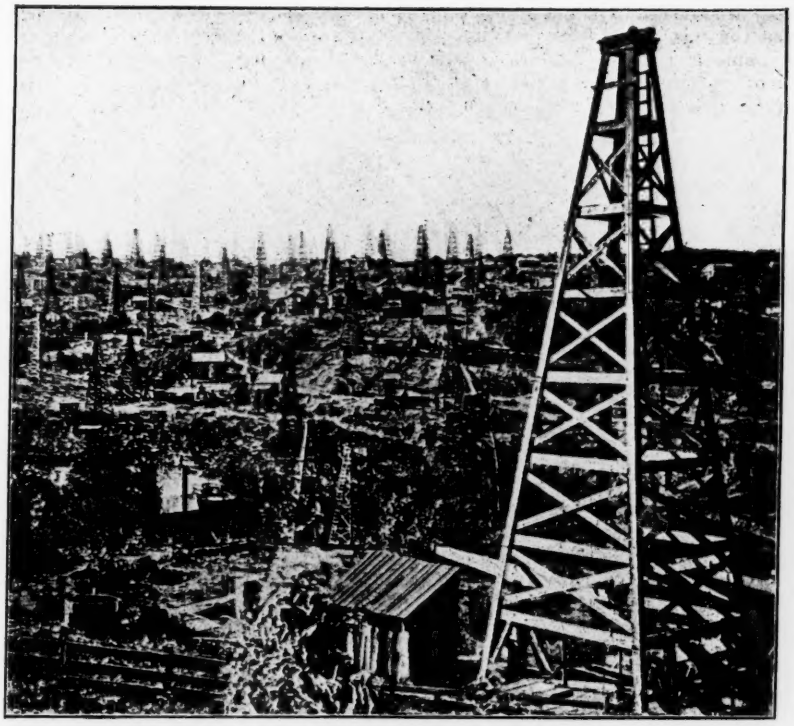
* See De Lapparent, "Traité de Géologie," 3me éd., p. 1457.

† KNOWLEDGE, Vol. XX., p. 209; also Vol. XXI., p. 77.

‡ See the striking remarks of Sir A. Geikie on subsidence between the Inner Hebrides and Iceland, in "The Tertiary Basalt-Plateaux of North-West Europe," *Quarterly Journal Geological Society.*, Vol. LII. (1896), pp. 399-405.

hundred feet high, and then fell, forming, together with the sand which it had carried up from the well, banks of sand enclosing lakes of oil, much of which ran out in a broad channel towards the sea. When, after about three months, the well was brought under control and capped, it was estimated to have yielded between two hundred and twenty thousand and five hundred thousand *tons* of petroleum, most of which was wasted. Mr. P. Stevens, our Consul at Baku, states that early in 1893 a well drilled in the district yielded oil at the rate of seventeen thousand seven hundred and forty-two tons daily, an amount far in excess of that of the Droojba well. Most of this oil also was wasted.

Oil is mainly obtained from the districts already mentioned; still, petroleum occurs in many countries and in most of the strata comprised between the older Laurentian rocks and the newer members of the Tertiaries. In the United States the principal deposits lie in Pennsylvania and New York (which are generally taken as forming one field), and in Western Virginia, Ohio, and Indiana. Notwithstanding the new fields that are being opened up, the amount of unprospected country is now by no means large; whereas, in Russia, enormous areas of proved oil territory, as well as still larger tracts of presumably oil-bearing land, are lying fallow because the small areas actually under the drill are capable of more than supplying the immediate demand. In Grosnia, and in the Kouban and the Crimea, as well as on the Apsheron peninsula, of which the oil district of Baku forms a small part, we have, for instance, proved tracts of land the output of which is likely to be enormous when the exigences of the market call for their development.



Derricks in the Oilfield of Bradford.

Petroleum occurs in commercially workable quantities in Canada, Galicia, Roumania, India, Java, and Sumatra; also in Japan, China, Peru, Germany, and many other countries; and it has been found in several parts of England, though not in sufficient quantity to admit of profitable working.

Taking the oils of America and Russia as the most important and typical, it is interesting to consider the different geological conditions under which they occur. The American oil is found in strata of the Silurian and Carboniferous epochs, and belongs to what is known as the "paraffin" series of compounds; while that of Russia may be referred to the Eocene and Miocene strata of the newer Tertiary series, and consists of compounds of the "benzene" family.

The American oil yields on distillation about seventy per cent. of kerosene oil suitable for ordinary lamps, together with lighter products forming the various petroleum "spirits," heavier oils used in gas manufacture, lubricating oils, paraffin wax, vaseline, and residuum utilized as liquid fuel. The Russian oil, on the other hand, yields less than half as much kerosene and light distillation products as does the American oil, and practically no paraffin, but it gives a higher and better yield of lubricating oil and a larger proportion of residuum, which, under the name "astatki," is used as fuel more in Russia than in any other country.

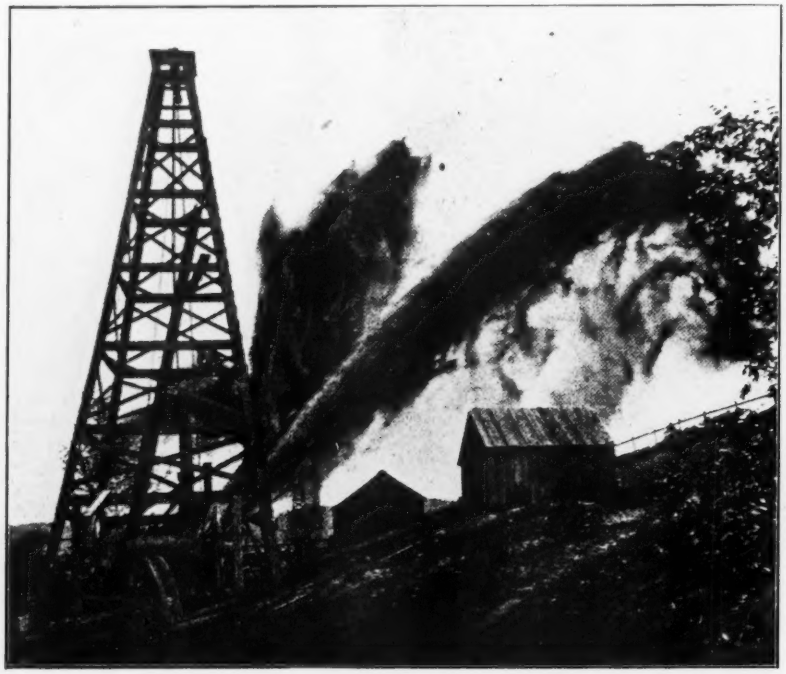
In America, as in all other countries, the earlier developments were due to the appearance of petroleum on the surface of the land, or to its occurrence in wells sunk for water or brine; but now the oil wells are very deep, those in the deepest drilled district—the Washington district of Western Virginia—averaging two thousand four hundred feet. The oil occurs mainly in the interstices separating the grains of sandstones, or between the crystals of a dolomitic rock; and experience has shown that it is necessary to raise the oil without regard to market requirements, or the whole may be pumped up through the wells of the neighbouring leaseholders, a condition of things which has led to a common practice of drilling round the boundary of the holding before commencing operations elsewhere.

In Russia, however, the conditions are different; the oil is usually found at comparatively shallow depths, often not more than one-fourth of the depth of the American wells. A loose sand, consisting of independent grains, comes up with the oil, and these grains of sand are a cause of serious trouble in the flowing wells on account of their cutting action on the caps with which the drillers endeavour to close the top of the well-casing to control the outflow. In the case of some of these flowing wells, the blast of sand has been known to cut through several thick steel caps before the flow could be stopped. The strata in which the oil occurs are also so disturbed as to practically constitute a large number of independent oil reservoirs, so that closely contiguous wells are found to be practically independent of each other, and there is no necessity for raising the oil until required.

Had space permitted, it would have been interesting to

trace the development of the modern drilling plant employed for the sinking of the oil wells, from the simple hand-worked appliances which, first used in the States for the sinking of brine wells, have become gradually superseded by the rapid and beautiful drilling plant comprised in what is known as the "American system." This, although not the only system in use, will be described as representative.

The first necessity is the "derrick"—a strong wooden framing resembling the structure at the pit-head of a colliery, and serving to support and control the working of the string of drilling tools. The derrick varies in height from about thirty feet, in the case of shallow wells, to seventy feet, in the case of the deeper wells, and the drilling tools are suspended from it on a stout rope, which is operated by an engine to raise and lower the tools. Somewhat complicated in their construction, the drills act by giving a blow at the bottom of the boring each time they are allowed to descend. A special appliance known as the "jars" is arranged to prevent the drill becoming jammed. It consists of two parts which slide upon each other and give a jar to the tool on the up-stroke, so that any tendency to jam is overcome. The total weight of a set of drilling tools is nearly four thousand pounds, and, in addition to this, a series of ingenious tools known as "fishing tools" has to be provided for finding and raising any part of the drilling tools which may become detached and remain in the well.



Well after being "torpedoed." A Side Discharge.

At intervals the tools are withdrawn, and the sand produced by the drilling is removed by pumps or balers. As the well is sunk it is cased throughout with metal tubing to avoid choking up by detritus or caving-in of the strata.

When the oil stratum is struck, or, more usually, when the well begins to show a decreased yield, it is common in America to explode a charge of dynamite—known as "torpedoing"—at the bottom of the well, in order to loosen the strata, and so facilitate the oil's access to the well. The oil is either pumped, or flows naturally, into a tank, from which it is conveyed by pipe lines to the refineries, as will be described later on.

ECONOMIC BOTANY.

By JOHN R. JACKSON, A.L.S., etc., *Keeper of the Museums, Royal Gardens, Kew.*

PAPAVERACEÆ.—Though this is a comparatively small order in the number of genera and species, and though the plants themselves are of the nature of small herbs, the order is one of considerable economic importance and interest. The plants are natives of temperate climates, particularly of Europe, and are well marked by their narcotic properties. By far the most important plant of the family is the opium poppy (*Papaver somniferum*), which, though it cannot be said to be known at the present time in a truly wild state, is probably a native of South-Eastern Europe and Asia Minor. The poppy has been cultivated from early antiquity for the sake of its dried juice, well known as opium. It is now very widely spread, but Asia Minor, Egypt, Persia, and India yield the principal supply; China also yields a large quantity. In Asia Minor, from whence the best opium used in medicine is obtained, the juice is collected by making incisions around the circumference of the poppy head or fruit while the plants are yet growing. The milky juice exudes slowly, soon becoming plastic or semi-solid, and turning brown; it is scraped off with a knife and placed on a leaf of dock (*Rumex*), which is carried in the left hand by the collector. When sufficient has been thus obtained to form a moderate-sized lump it is rolled up in the leaf and allowed to harden. In India the mode of collection is somewhat different; the fruits are scarified longitudinally by a kind of small lancet, the juice is scraped off in little scoops, and poured into bowls, in which part of the moisture separates. In the factory it is mixed or stirred in vats to insure uniformity of substance, and then made into balls of about six inches diameter and covered with the dry poppy petals. In this condition it is stacked in racks in the opium store, and when required for exportation to China it is packed in chests divided into numerous compartments, each division holding one ball. Indian opium contains a much lower percentage of morphine than that from Asia Minor, and is consequently of much less value for medicinal purposes. It is, however, largely used for eating and smoking.

The cultivation of the opium poppy in cool countries is chiefly for the sake of the capsules and seeds, the former for supplying the shops with "poppy heads" for making fomentations for allaying pain as well as for making syrup of poppies, and the latter for the sake of the oil they contain, which, when clarified, is of a sweet nature and of a pale straw colour, and is used for mixing with, or as a

substitute for, olive oil for culinary purposes, and the residue or marc is used for feeding cattle. Under the name of "maw seeds" they are given to cage birds. In this country the opium poppy is cultivated in many medicinal gardens, notably at Bodicote, near Banbury, Hitchin, and other places.

CRUCIFERÆ.—The plants constituting this order are mostly of an herbaceous character, particularly abundant in the temperate parts of the northern hemisphere. Though they mostly possess pungent or biting properties, none are poisonous, but, on the contrary, are eminently wholesome and antiscorbutic. The following best known examples of the order will illustrate this. Horse radish (*Cochlearia armoracia*), a perennial herb naturalized in this country, occurring in damp, waste places, and found throughout the greater part of Europe. Under cultivation it forms a thick, somewhat fleshy root, and is much valued as a condiment. Mustard is another condiment of equal or greater value, and is the finely pulverized seeds of two species of *Brassica*—*B. alba* the white, and *B. nigra* the black mustard. They are annual plants widely distributed over Europe, *B. alba* occurring also in Asia Minor, Algeria, and China, and cultivated in the home counties of Essex and Cambridgeshire; while *B. nigra* is also found in Asia Minor, as well as in North Africa and North-West India, its cultivation in this country being chiefly carried on in Lincolnshire and Yorkshire. In the preparation of mustard, or flour of mustard of commerce, the seeds of both species are used mixed, and great care is taken in reducing them to a very fine powder which is sifted through a fine silk gauze. Besides the use of mustard for table purposes, it is an important medicinal agent on account of its powerful stimulant and rubefacient properties. The cabbage (*Brassica oleracea*) is another illustration of a valuable esculent belonging to this important order of plants. In its wild state it is abundant on the cliffs by the sea-coast in many parts of England, especially in the south-eastern counties. The effect of cultivation has produced marvellous changes in this plant, giving us all the varieties of brocoli, Scotch kale, Savoy, Brussels sprouts, cauliflower, and even the red cabbage. The same power of culture has also changed the woody root of the common wild turnip (*Brassica campestris* var. *Rapa*) into the fleshy, globular root of our gardens, while the Swede turnip has sprung from another variety of the same species; and the rape, again, so largely grown by us as a green fodder, and on the Continent for the sake of its seeds, from which is expressed rape or colza oil, has originated from still another variety.

The radish (*Raphanus sativus*) is still another of the esculent cruciferous roots. The plant is unknown in its wild state, but it has been suggested that it may have sprung from an allied species of the Mediterranean coast. In the early ages it was extensively cultivated in Egypt, and found its way into England about the middle of the sixteenth century. Gerard mentions four varieties as being known in 1597. We cannot leave this interesting family of plants without a reference to woad, the blue colouring matter used by the ancient Britons to stain their skins, and produced by *Isatis tinctoria*. At that early period its culture seems to have been general for the purpose mentioned above, as well as for dyeing cloths, but in later times the general introduction of indigo seriously interfered with the use of woad; and though it is still manufactured in some parts of the Continent, its preparation in this country is fast dying out, and at the present time is carried on only in the neighbourhood of Wisbech, and there it is still made in the most primitive fashion.

CAPPARIDEÆ.—This comparatively small order is composed of herbs and shrubby plants, very rarely trees, chiefly tropical, abundant in Africa, America, and India. The order is marked by the presence of pungent and stimulant properties, in this respect somewhat resembling the crucifers. Only one plant, however, in the order has any special economic value, and that perhaps of more interest than actual commercial value. We allude to capers, which are the flower buds of *Capparis spinosa*, a scrambling bush of the Mediterranean region. The plant is cultivated in some parts of France, as well as in Italy, for the sake of the flower buds, which are gathered and pickled in vinegar. The imports to this country are very small, the use of capers being only for culinary purposes.

CISTINEÆ.—Shrubs or herbs generally known as rock roses, natives chiefly of Southern Europe and Northern Africa. They are noted for the presence of a fragrant balsamic resin. The best known plant is *Cistus Creticus*, a native of Crete and Cyprus, Macedonia, Rhodes, and other Greek islands. A resin known as ladanum is collected from the leaves and branches by whipping or bruising them with an instrument consisting of long leathern thongs attached to a rake-like frame. The thongs become coated with the resin, which is afterwards scraped off and moulded into small cakes. In Cyprus, ladanum is often collected by combing the resin from the fleeces of the sheep, which become loaded with it while they are pasturing among the plants. It possesses stimulant and expectorant properties, but it is seldom or never used in medicine at the present time; it nearly all goes to Turkey, where it is used for fumigation and as a perfume.

BIXINEÆ.—A group of shrubs or trees, natives of the tropics, and found mostly in the East and West Indies and Africa. The principal economic plant of the order is the anatto (*Bixa orellana*), a tree twenty to thirty feet high, native of tropical America, but now cultivated in many tropical countries for the sake of the seeds, which are small, of a bright red colour when fresh, and of a waxy nature. It is this red coating of the seeds that forms the anatto of commerce, and it is removed by placing the seeds in water, which is stirred till the colouring substance is detached, when it is strained and evaporated to different consistencies and used for colouring cheese and butter, as well as for dyeing silks. Large quantities of these seeds are regularly imported.

Amongst other economic plants of this order of less importance may be mentioned the chaulmugra (*Gynocardia odorata*), a large Indian tree, producing hard-skinned globular fruits about four inches in diameter. These contain numerous seeds embedded in the pulp, and from these seeds an oil is expressed known as "chaulmugra oil." It has an established reputation in India as a medicinal oil, and was introduced a few years ago to this country for the treatment of rheumatic affections and skin diseases. Its use has now, however, quite died out.

GUTTIFERÆ.—Trees and shrubs are the plants which compose this order, and they are all natives of tropical countries. They are for the most part resinous, besides which many of them yield oils or fats. The best known resinous products are those furnished by species of *Garcinia* and collectively known as "gamboge." The most important of these are *Garcinia Hanburyi*, yielding the best quality, or Siam gamboge, and *Garcinia Morella*, giving the Ceylon kind. Gamboge is obtained from the first-named plant by making a spiral cut through the bark of the tree as it stands; the yellow juice readily flows and is received into the hollow joints of bamboos, where it is left until it solidifies, after which the bamboos are broken away, leaving

XUM

what is known in commerce as "pipe gamboge," which is the best and purest quality, the second quality being that which is collected in lumps. In Ceylon gamboge is collected either from incisions made in the bark or by cutting out pieces of it, from which the yellow juice oozes and hardens on exposure, and the lumps are then scraped off. Gamboge possesses powerfully purgative properties, and was at one time used in medicine. At the present time it is only used in veterinary practice. Its chief use, however, is as an ingredient for lacquering brasswork and as a pigment in water-colour drawing. The well-known mangosteen is the fruit of a *Garcinia—G. mangostana*. It is a moderate-sized tree of Malacca and the Malay Archipelago, but it has been introduced into other tropical countries. It is the juicy pulp surrounding the seeds which is the delicious morsel that has caused the mangosteen to be classed as the best of all tropical fruits.

Many other plants of this order might be mentioned as yielding important economic products, but space will not permit us to do so.

TERNSTRŒMIACEÆ.—This is an order of trees and shrubs chiefly tropical. It is not marked by any characteristic property. In some of the South American species the trees are noted for their hard and heavy woods and the sweetness of the seeds, or nuts, as they are called, the Souari nut of our shops (*Caryocar nuciferum*) being one of them. The most important plant in the order—indeed, one of the most important in the whole vegetable kingdom—is the tea plant (*Camellia thea*). From its early and very extensive cultivation in China it was for a long time supposed to have been a native of that country. It has, however, been more recently shown to have originated in Upper Assam, and to have been introduced to China at a very early period. In like manner it was supposed for a very long time that the black and green teas of commerce were the produce of distinct species. This has likewise been shown to be a fallacy, and it is now well known that black and green teas are prepared from the same plant by different methods of drying and curing. Thus, for green tea, the leaves after gathering are not allowed to lie so long as those intended for black tea before they are rolled and roasted. By this means the fermentation during the process of withering is avoided, and the leaves in consequence retain much of their natural green colour. Many details, which cannot be explained here, also have to be followed, resulting in the two commercial kinds of tea—black and green. In connection with the increased demand for tea the world over, it will be interesting to note that to meet that demand the range of the cultivation of the plant has considerably extended in recent years. Thus we find it thoroughly established in Ceylon, while in Japan, Java, and in Natal, excellent tea is grown and prepared.

The following figures will give an idea of the proportions of the commerce in tea so far as Great Britain is concerned:—The total imports for the year 1897 amounted to two hundred and sixty-nine million, thirteen thousand, four hundred and eighty-two pounds, of the value of ten million, four hundred and forty-three thousand, one hundred and four pounds.

DIPTEROCARPEÆ.—The plants composing this order are for the most part large forest trees of India, noted for the strength and durability of their timber and for the valuable resinous products they yield. The best known in the first category is the sal or saul tree (*Shorea robusta*), a tree forming extensive forests over a wide range in India, where the timber is almost, if not quite, of equal value as teak, and is in great demand for gun carriages, railway sleepers, and building purposes generally. It, moreover, yields a quantity of resin known as "dammar," and used for preserving the woodwork of boats. From several species of *Dipterocarpus*, notably *D. alatus*, *D. turbinatus*, and *D. trinervis*, an oleo-resin known as "wood oil," or "Gurjun balsam," is obtained, chiefly from the coast of Burma and the Straits of Malacca. To collect the balsam, the trees are tapped at the end of the dry season by making several deep incisions with an axe into the trunks and scooping out a good-sized cavity. Fire is lighted in this hole, and when the wood has become heated or scorched the balsam begins to flow. After collection it is allowed to settle, when the clear liquid or oil separates from the more solid or resinous portion. It is said that as much as thirty or forty gallons has been obtained from a single tree in one season. Though it is used in India as a substitute for balsam of copaiba, its chief use is as a natural varnish for preserving woodwork from atmospheric effects or the attacks of white ants. The Sumatra camphor tree (*Dryobalanops aromatica*) is of considerable interest in consequence of its peculiar habit of forming masses of camphor crystals in clefts of the trunks. It is much less volatile than ordinary commercial camphor, and fetches a high price amongst the Chinese, by whom nearly the whole of the produce of Sumatra is taken, and these people believe it to possess many remarkable properties. It does not reach Europe, except occasionally as an article of curiosity.

The only other product of the *Dipterocarpeæ* that space will allow us to mention is that known as "piney resin," or "Indian copal," the produce of *Vateria indica*, a tree of Malabar. This resin is of a semi-fossilized character, and is used slightly in the preparation of varnish. From the large fleshy seeds a kind of fat or tallow is obtained, which is used in India for making candles, and is known as "piney tallow."

WEATHER ACCOUNTS.

By ALEX. B. MACDOWALL, M.A.

AN analogy might be traced between the fluctuations of weather and those of a banking account. And we might deal with the plus and minus values of the former (with reference to an average) as we might with sums deposited in a bank and sums withdrawn, so as to show the position of affairs at any given date in relation to a previous date.

Thus, suppose a man opens a banking account, which he is allowed to overdraw. The first week he deposits ten pounds and the next ten pounds. Next he draws five; then deposits ten; then draws thirty. The final result obviously is that he is five pounds "to the bad." And this set of transactions, and the position each week, might be simply represented thus:—

	1	2	3	4	5	
Transactions	...10 +	10 −	5 +	10 −	30	= −
State of Account	...10 +	20 +	15 +	25 −	5	

On the other hand, take as a simple case of weather the monthly amounts of rain in London last year. Mr. Symons, in his magazine, gives us the plus or minus values in which these are referred to an average. We proceed accordingly thus:—

Jan.	Feb.	Mar.	April.
+ ·43	+ ·87	+ 1·81	− ·17, etc.
+ ·43	+ 1·30	+ 3·11	+ 2·94, etc.

The second line, completed, we may plot as a curve (H, Fig. 3).

We often hear questions like this, "Have we had more

or less than our share of rain?" This curve supplies answers for the months of 1897. The first three months were wet. This excess was brought down in the next four; so that by the end of July we had had nearly our proper amount. But by the end of the year there was about two and a half inches (as we may say) still due.

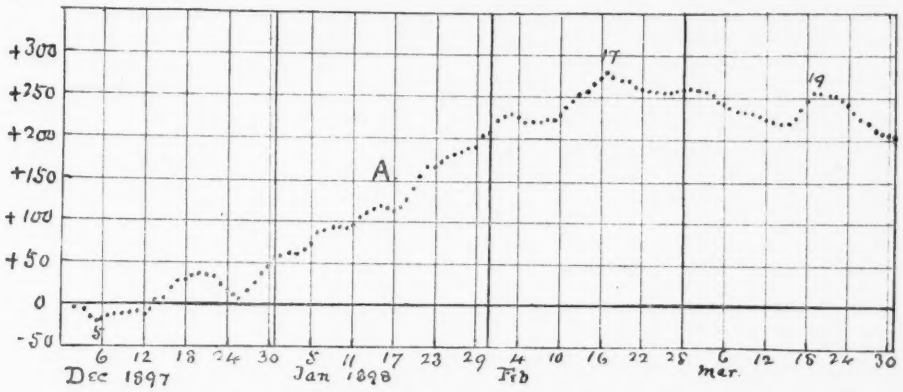


FIG. 1.—Gain and Loss Curve of Daily Temperature at Greenwich last Winter.

Let us see what kind of curve we get from the daily temperatures (at Greenwich) in the remarkably mild winter we have lately passed through. (The relation of these to the average is given in the *Weekly Return*.) The curve is that marked A (Fig. 1).

In these curves a rise means a plus value, and a fall a minus; we may speak of the one class as "gains," the other as "losses"; and we see that in this curve, from the beginning of December to February 17th, the gains were much more than the losses. Neglecting for the present the individual amounts of gain or loss, we find that the warm days were much more numerous than the cold. After February 17th the balance was the other way. Here are some figures: from December 1st to February 17th we had sixty-one warm days and only eighteen cold; thereafter thirty-two cold days and only ten warm. Will this downward course of the curve continue some time? It would be difficult to say.

We may take a wider survey in this matter of temperature. Consider the years as hot or cold. Here is a curve (B, Fig. 2) which shows, in the case of Greenwich, the result of the method as applied to the years since 1841. Up to 1878 there has been a general rise; since 1878, a general fall. More hot years than cold in the former case (twenty-three to fifteen), more cold than hot in the latter (twelve to seven). The rise since 1892 may be the beginning of a long general ascent; but it seems not inconsistent with our being still on the "down grade."

Can we go further back with confidence? Earlier figures are in some uncertainty. If we take a table of estimated Greenwich temperatures, by Mr. Glaisher, in the *Philosophical Transactions* for 1850, and extending from 1771 to 1849, and apply our method, we get the curve C. An interesting table by Dr. Buchan, for the North-East of Scotland (chiefly Gordon Castle and Culloden), from 1764 to 1892, yields the curve D. There is a degree of similarity between these two curves, and they may be taken to afford a general idea of the truth. They dip down to low points

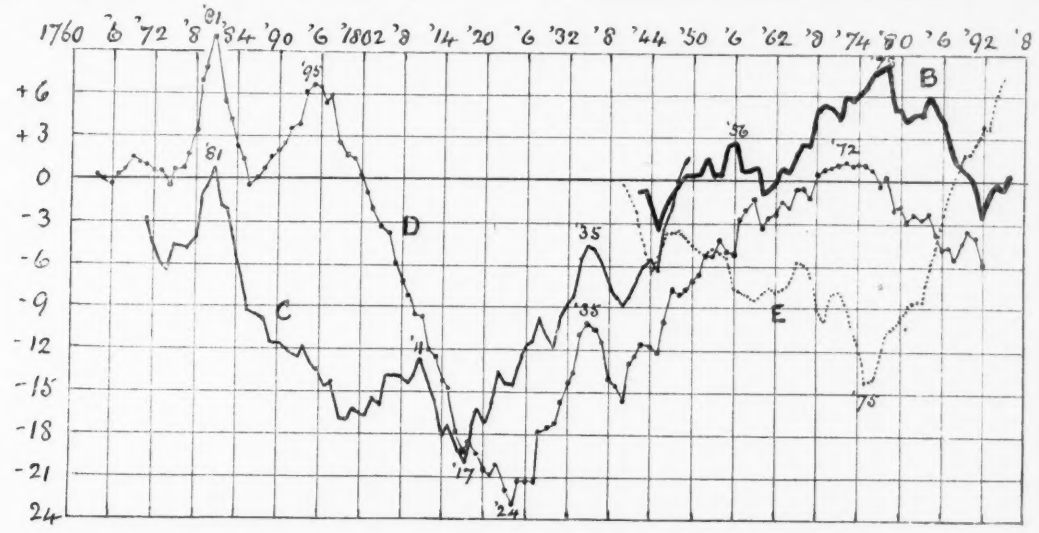


FIG. 2.—Gain and Loss Curves of Annual Temperature, Greenwich, North-East Scotland, and Harvard.

in the second and third decades of this century; after which comes a long rise to the seventies. The first twenty years of our century evidently included some very intense cold. Perhaps the severest winter of the century (thus far) is 1813-14, when a fair was held on the Thames, and there was a snowstorm lasting forty-eight hours.

It is a curious fact that in America the weather is often opposite to ours. Thus, if winter is severe on the continent of Europe it is generally mild in America, and *vice versâ*.

How does America show in temperature from our present point of view? E is a "gain and loss" curve, as we may call it, for Harvard Observatory, from 1841. It is distinctly opposite in character to that for Greenwich. Up to 1875, more cold years than hot; since 1875, more hot years than cold. A similar kind of variation might be shown for Chicago, and, doubtless, other places.

In all these curves, we may here note, it is the general trend of the curve that has to be considered, rather than the relation to the average line. For the starting point is

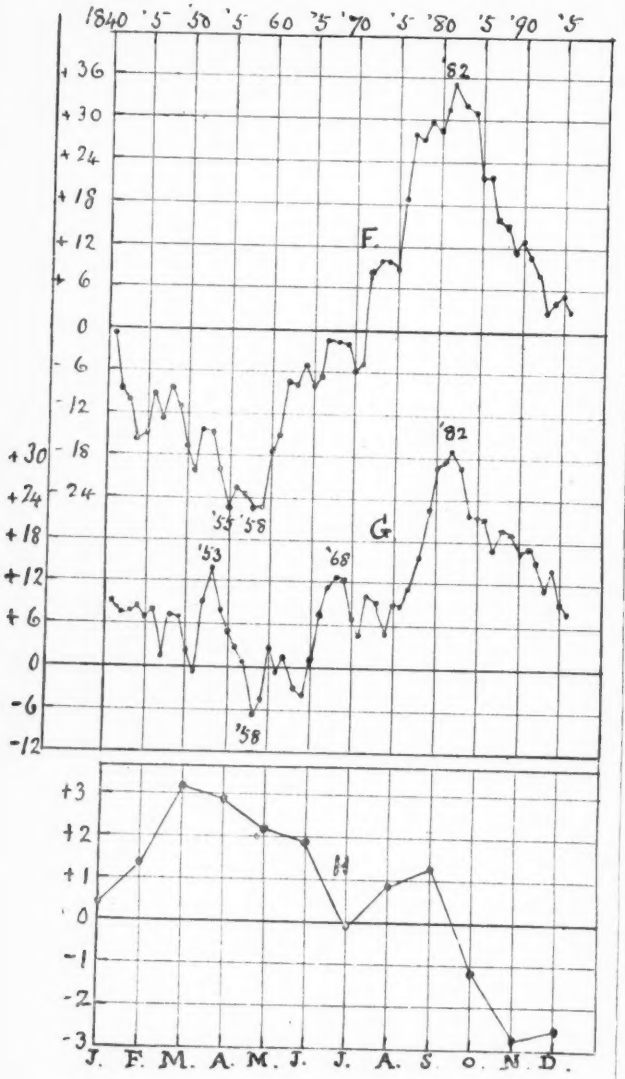


FIG. 3.—Gain and Loss Curves of Rainfall, Edinburgh and Greenwich (years), and London (months of 1897).

chosen arbitrarily, and we always commence near the average line. Referring to curve D, if we commenced in 1824 we should get a curve wholly above the average line, instead of mostly below it, as in the diagram.

We may now, in conclusion, briefly glance at rainfall. The annual rainfall at Edinburgh from 1841 to 1896 (according to Mr. Mossman's figures), treated by our method, yields the curve F (Fig. 3); and that for Greenwich the curve G.

In both of these we may observe a gradual rise from 1858 to 1882; more wet years than dry. Thus, in the case of Edinburgh, of these twenty-five years, sixteen were wet and only nine dry. Since 1882, again, the dry years have preponderated; in Edinburgh ten dry to four wet. From the general aspect of these curves we may, perhaps, be inclined to think the preponderance of dry years may continue some time further.

The method here illustrated does not seem to have been much used in this country, but is capable, I believe, of throwing some light on the vagaries (as we often call them) of our weather.

THE PRISMATIC CAMERA AT THE RECENT ECLIPSE.

By J. EVERSHED, F.R.A.S.

SPECTROSCOPIC research formed an important feature in the work of most of the astronomical parties who went to India to observe the total solar eclipse of last January, and photographic methods, which have so largely replaced eye observations at recent eclipses, were, it is needless to add, employed at every station where this analytical method was in vogue.

Owing to the ideal condition of the weather all along the line of central eclipse, a large number of very beautiful photographs are the result. The amount of interesting material thus secured, and which is now available for discussion, certainly exceeds anything obtained at any previous eclipse.

Among the various lines of research undertaken by spectroscopists, perhaps the largest share of attention was given to the study of the spectrum of the layer of gases lying immediately above the dazzling photosphere, and known as the "flash spectrum."

It may be well to explain, for the benefit of those who are unfamiliar with the subject, the conditions under which this spectrum is revealed during an eclipse. Outside the visible surface of the sun, and covering the entire sphere pretty uniformly, there exists a stratum of gas of considerable depth and comparatively simple composition, known as the "chromosphere." Its spectrum of bright lines indicates the presence of the three elements calcium, hydrogen, and helium. This layer and the prominences arising from it may be seen at all times by the aid of powerful spectroscopes; but the base of the chromosphere—that is, the region lying within one or two seconds of arc of the photosphere—is not accessible to ordinary spectroscopic observation, on account of the perpetual unsteadiness of the telescopic image of the sun, and the very intense atmospheric illumination so near to the sun's edge.

Now, during the progress of a total eclipse, the moon, advancing from the west, gradually covers up the photosphere until only a thin crescent remains on the east side, and this rapidly narrows down and finally vanishes altogether; when this occurs, however, the chromosphere lying outside still remains uneclipsed on the east limb, and even the very lowest strata are uncovered near the point where the last streak of photosphere disappeared.

It is just here that the most interesting and beautiful spectral phenomena are revealed; bright lines flash out in hundreds—there seems literally to be a *shower* of bright lines all along the spectrum the moment the photospheric light is withdrawn—but it is only momentary; the steadily advancing moon almost immediately occults the lowest gaseous strata and only the ordinary chromospheric spectrum remains.

This beautiful phenomenon can therefore only be seen or photographed at the moments of disappearance or reappearance of the photosphere at the beginning and end of the total phase respectively. Under the average conditions of an eclipse, perhaps not more than two seconds are available just as totality comes on in which the flash spectrum may be photographed in its full splendour; and if the observer is discerning enough to know exactly when the sun is going to burst out again at the end of totality, he will have another two seconds in which to expose a second plate!

It has been estimated that our opportunities for studying the corona do not amount in the aggregate to more than some hours per century, and the progress of knowledge is, in consequence, not rapid. How long it will take to unravel the mysteries of the flash spectrum it is hard to say, seeing that the time available for its study must be reckoned in *minutes* per century. This method of estimation is, however, certainly unjust to the photographic plate, which enables us to study at leisure so very transient a phenomenon.

A great variety of photographic spectroscopes were used at the recent eclipse, but all may be classed under two heads, viz., slit spectrographs and prismatic cameras. The great advantages possessed by the latter for eclipse work were first pointed out by Sir Norman Lockyer, who employed them with great success at the eclipse of 1893, and again in 1896, when Mr. Shackleton first succeeded in photographing the flash spectrum at his station in Novaya Zemlia. The crowning success for the prismatic camera is the splendid photograph of the flash which Sir Norman Lockyer has obtained at the recent eclipse with his six-inch instrument in the hands of Mr. Fowler.

The photographs which accompany this article were obtained at the recent eclipse with a small instrument of this class, which I constructed in 1896 for the eclipse of that year. Without going into details as to the design of this particular instrument, I may say generally that the prismatic camera is the simplest of all spectroscopic appliances. It consists essentially of a prism placed in front of a camera lens. There is no slit or collimator, which in the ordinary spectroscope are used to give purity to the spectrum, and consequently it is not possible to photograph spectra from extended sources of light, such as the disc of the sun. But the prismatic camera is particularly well adapted for photographing the spectrum of the solar atmosphere during an eclipse, because, as before explained, when the disc is entirely covered by the moon there remains a thin crescent of light due to the layer of gases outside, and which acts the part of a curved slit. If the moon and sun were precisely equal in apparent size this would extend all round in a ring, and would produce considerable confusion in the spectral images; but under ordinary circumstances the moon is slightly the larger in angular diameter, so that early in the total phase the chromospheric gases appear as a half circle or crescent on one side only, while later on this is in turn eclipsed and the opposite portion is uncovered.

In the succession of photographs given in the plate it will be noticed that the spectral images of these crescents exhibit this change, which occurs about the time of mid-totality (between Nos. 4 and 7). It will of course be understood that, owing to the essential nature of gaseous radiation, and to the wonderfully complete mixture of gases existing at the base of the chromosphere, an enormous number of distinct images or spectrum "lines" are shown in the photographs taken near second and third contact. The pair of very strong images to the left hand of the central portion of each spectrum are those due to the well-known radiations of calcium vapour, namely, H and K; they give complete images of the chromosphere and prominences—or, rather, as much as was uncovered by the moon at the time each photograph was taken.

Before proceeding to describe in detail the results obtained, I will give a brief description of the arrangements I made for this work at the camp of the British Astronomical Association stationed at Talni.

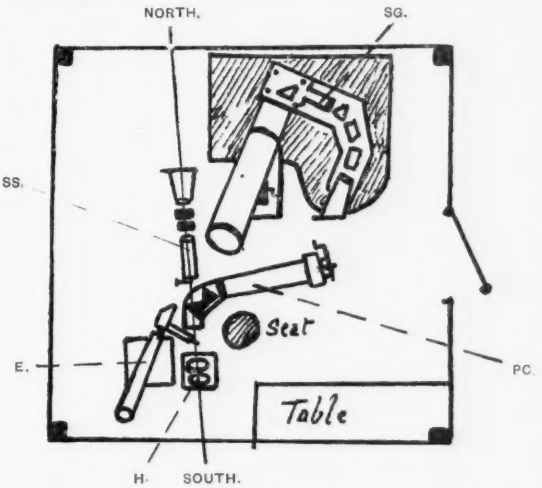
My plan of work was first to obtain a series of ten photographs with the prismatic camera during totality, and including, if possible, the flash spectrum at both second and third contacts; secondly, to photograph the flash spectrum on a larger scale with a large slitless spectrograph attached to a six-inch telescope; and, thirdly, to expose a single plate to the spectrum of the corona during the whole time of totality by means of a slit spectrograph containing quartz prisms.

Besides these three photographic instruments I had available a four-inch polar heliostat, kindly placed at my disposal by Mr. W. H. Maw; and a three and a quarter inch equatorial telescope provided with a powerful solar spectroscope, with which I intended to actually observe the flash of bright lines at second contact, and thus determine the exact moment when to expose the photographic instruments.

The heliostat, which I arranged with two four-inch mirrors instead of one, was used to supply light to the prismatic camera and to the slit spectrograph, both these being mounted on fixed supports firmly bedded in cement. The six-inch telescope with its spectrograph was mounted equatorially, but without any driving gear, and was pointed directly at the eclipsed sun.

As there would be no one available on the day of the eclipse to assist me, the three photographic instruments had to be arranged with their exposing shutters near together, so that I could work them all while seated near the telespectroscope.

The diagram will show better than any description the disposition of the various instruments within the observing hut.



PLAN OF OBSERVING HUT.

E. Equatorial Telespectroscope; H. Heliostat; PC. Prismatic Camera; SG. Spectrograph with Six-inch Object Glass; SS. Slit Spectrograph with two Quartz Prisms.

Thanks to the facilities afforded by the Indian Government in providing workmen and materials, and to the

very attentive way in which all our needs were provided for by the Deputy Commissioner of the district, Lieutenant Morris, I was able to get everything erected and in working order during the fortnight preceding the eclipse. In adjusting the instruments and putting together the six-inch telescope and spectrograph I had also the advantage of receiving most efficient help from Captain Molesworth, R.E., without whose skilled assistance it would have been impossible to get all ready in time.

On the day of the eclipse the actual procedure was as follows:—About ten minutes before totality the heliostat was started going and the mirrors adjusted. Then the exposing cap of the prismatic camera was put on and the first plate drawn up into position by means of a rack-and-pinion arrangement which I had made for this instrument to obviate the necessity for "changing plates" after each exposure. Next, the exposing shutter of the slit spectrograph was closed and the dark slide drawn out ready.

At eighty-eight seconds before second contact the six-inch telescope was adjusted and clamped in such a position that the diurnal motion would carry the image of the eastern edge of the sun exactly into the middle of the field of the spectrograph at the moment of second contact. This was effected by moving the telescope until the image of what remained of the sun touched a certain mark previously made on a screen placed in the focal plane, and keeping it there by following in R.A. until the chronometer I was using indicated eighty-eight seconds before totality.

During the last half-minute before the eclipse was total I began exposures with the prismatic camera, taking two instantaneous photographs of the cusp spectrum, and then drawing another plate into position ready for the "flash."

Now, all being ready, only a few seconds remained before the bright lines of the flash spectrum might be expected to appear. The gloom of the approaching shadow was already increasing at an alarming rate. I turned to the visual spectroscope, took off the slit head, and watched the spectrum of the last remaining thread of sunlight without any slit. The well-known groups of dark lines composing the ordinary solar spectrum were seen at first just as though the slit had not been removed, but they were curved arcs instead of straight lines, each taking the form of the little crescent of photosphere remaining uncovered.

The band of continuous spectrum in which these dark lines appeared was seen to be rapidly narrowing, but, instead of thinning down to a single thread, the roughness of the moon's edge caused it to suddenly break up into a number of strips with dark spaces between, and at this instant the bright lines flashed out in hundreds between and across the streaks of continuous spectrum. I was astonished at the suddenness of the reversal from dark lines to bright, and at the brilliancy and extreme sharpness of the lines; many of them extended for thirty degrees or more round the limb of the moon, but interrupted here and there by the projecting lunar mountains.

Without waiting for further developments I immediately exposed the prismatic camera and the large spectrograph, in hopes that the photographic plate would be equal to the occasion and duly record this wonderful display.

In the resulting photograph (No. 3) certainly not all of the finer lines are depicted which I could see reversed in the part of the spectrum I was observing. But in the ultra-violet, where the definition is best, an extraordinary wealth of fine lines are shown; and this end of the photograph gives a good idea of what I actually saw near the group *b* in the green.

Immediately after second contact I made an instantaneous exposure with the prismatic camera—the fourth of the series—and then started a series of long exposures, at the same time opening the shutter of the slit spectrograph.

During the first long exposure I left the seat near the heliostat and closed the slide of the large spectrograph, reversed it, and opened again ready for the second flash. Then I had to turn the right ascension handle four revolutions to bring the west limb into the field of the spectrograph at third contact. The forty seconds occupied in this way with my back to the eclipse was an ordeal which I trust I may never again have to undergo! After returning to the seat I closed the long exposure and started another; then I had a look, for the first time, at the corona. With a pair of binoculars I examined the beautiful streamer on the south-west side which was so successfully photographed by Mrs. Maunder (*see* the May Number of KNOWLEDGE). But almost before I could gain any very distinct impressions I was interrupted by the time caller, only twenty more seconds remaining before the sun would reappear! It was necessary to close the long exposure, expose another short one, and then look out for the flash again.

Fortunately I made the exposure for the second flash spectrum just as the first points of sunlight burst into view on the west limb, forming what is known as "Bailey's Beads." (*See* No. 8.)

Two more snap shots with the prismatic camera taken in rapid succession completed the programme.

The whole performance seemed to have gone off without any serious hitch, but too late I discovered the slit spectrograph still open, with the crescent sun right across the slit! I had forgotten to close the shutter in the hurry of the last moments of totality.

The number of photographs secured altogether was thirteen; one with the slit spectrograph, two with the large spectrograph, and ten with the prismatic camera.

The single photograph obtained with the first named failed from the above-mentioned cause, the direct sunlight and halation nearly obliterating the faint coronal spectrum.

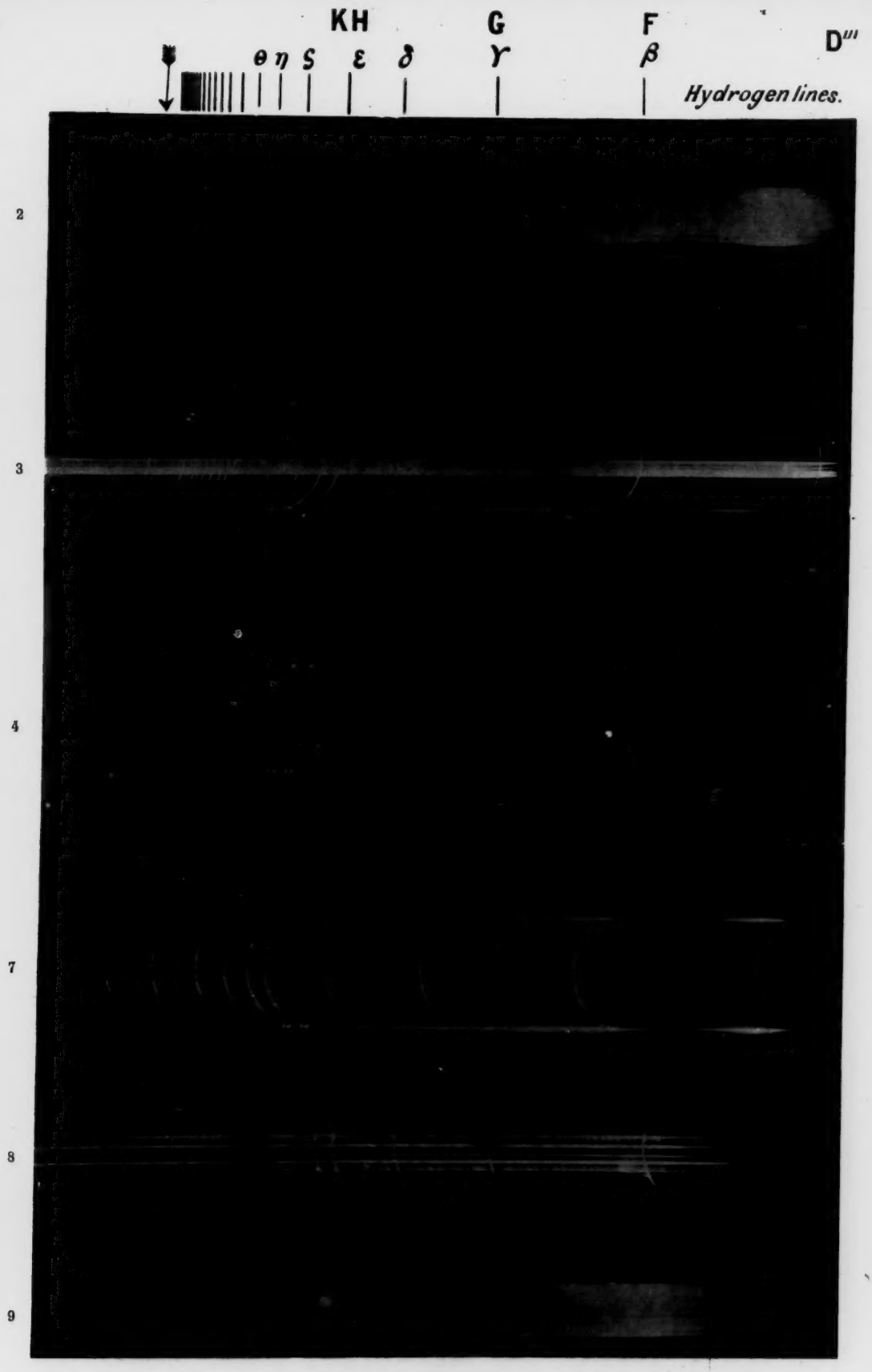
The large spectrograph yielded two negatives of the flash spectrum which show a considerable number of lines in a limited region of the spectrum, but on the whole they do not quite come up to expectation. The best results were those obtained with the prismatic camera. This instrument gave images of the spectrum extending from λ 600 in the orange to λ 338 in the ultra-violet. The scale of the original negatives is ·33 inch to the moon's diameter and one inch from F to H, the total length of spectrum photographed being 2·8 inches.

All the ten exposures yielded good negatives. Nos. 1, 2, 9, and 10 of the series give the spectrum of the cusps just before and just after the total phase. They show the Fraunhofer dark-line spectrum bordered with bright lines, and in No. 10 *all* the dark lines in the ultra-violet end in a short bright line.

The flash spectrum lines are shown in Nos. 3, 7, and 8. In No. 3 they are beautifully defined in the ultra-violet from H upwards, and this photograph is certainly the finest of the set. It will be necessary to study it in great detail by means of enlargements and with the help of the Fraunhofer spectrum (obtained under precisely the same angle of incidence) given in Nos. 1 and 2.

Of the remaining plates, No. 4 reveals a very curious feature in the prominence spectrum. In the ultra-violet are seen a succession of little dots due to the hydrogen radiations, and at the point where these terminate (at λ 3666) the spectrum abruptly changes its character and becomes a continuous one, a delicate line running from the last dot to the end of the plate.

XUM



ECLIPSE SPECTRA.

Photographed with Prismatic Camera, 2¼ inches Aperture, 36 inches Focus.

XUM

The long exposures made near mid-totality show the distribution of "coronium" in the corona. The well-known radiation of this gas, 1474 K, is, in these, shown to correspond more or less with the general structure of the corona; but it is very much brighter on the east side than on the west, where it is hard to trace it at all.

Six out of the ten photographs taken are reproduced in the plate, enlarged about two and one-third times. The series number is given beside each spectrum. Much of the delicate detail shown on the original negatives is inevitably lost in the reproduction, although the main features are well brought out. In referring again to the flash spectrum, as seen in Nos. 3 and 7, I would call attention to the beautiful sequence of the hydrogen lines (the positions of these referring to No. 3 are given at the top of the plate). I do not know that these lines have ever before been photographed in such completeness in the chromosphere spectrum. In the original negative twenty-six or twenty-seven lines can be counted, starting with the line α at the red end. In the ultra-violet they become so closely crowded together that it is not easy to say exactly how many there are and where the series ends. According to the well-known empirical formula of Balmer, which expresses with such extraordinary accuracy a series of numbers given by nature, the limit should be at λ 3647, a position in the spectrum which is indicated by an arrow at the top of the plate. In the photograph, however, there is a beautifully regular gradation in the intensity of the lines, which become fainter and fainter as this limit is approached, so that line No. 27 (λ 3664) is so exceedingly faint as to be barely distinguishable, and it apparently forms the termination of the series.

Another point which is well shown in No. 3 is that, if we except the ordinary chromosphere lines (those of calcium, hydrogen, and helium), all the fainter lines due to the flash spectrum proper are of the same length and form, a well-defined band of even width running from end to end of the spectrum. This shows that the low-lying gases at the base of the chromosphere form a well-defined layer pretty definitely bounded, and not fading by insensible gradations into the higher portions of the chromosphere.

An estimate based on the width of this band of bright lines gives for the depth of the layer about one and a half seconds of arc—or say seven hundred miles—the total depth of the chromosphere itself being some eight seconds of arc, or three thousand six hundred miles.

The limits of this article preclude my entering upon the discussion as to the relation between the flash spectrum lines and the Fraunhofer spectrum, beyond saying that, from a careful consideration of the facts so far brought to light, I am inclined to believe that the flash spectrum does in fact represent the upper portion of the layer which by its absorption gives us the ordinary dark-line spectrum, as was held by Prof. Young, who first discovered the so-called "reversing layer" at the eclipse of 1870.

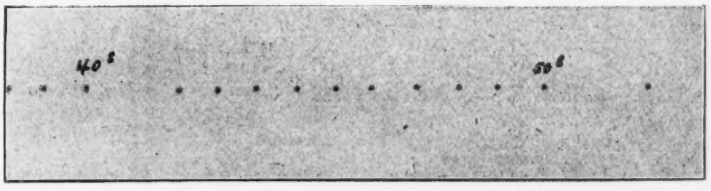
I think that too much stress has been laid upon the fact that, while the flash spectrum lines correspond in position with the Fraunhofer lines, yet in relative intensity there are marked differences. This, it seems to me, is only what we should expect to be the case when we consider that in the one case we are looking tangentially through the higher parts of the layer (which, it is to be remembered, is some seven hundred miles in depth, with a probable enormous increase of density at the base), while in the other the line of sight passes entirely through the layer from top to bottom.

OCCULTATION OF 26 ARIETIS OBSERVED PHOTOGRAPHICALLY.

THE disappearance of a bright star when occulted by the moon is always a striking phenomenon. There is no celestial event whose time is susceptible of more precise determination. For many years various plans have been suggested, both here and elsewhere, by which this time could be determined with greater accuracy than by ordinary visual observation. In fact, the apparatus for photographing the eclipses of Jupiter's satellites, used here for several years, was devised in part for this purpose.

On February 25th, 1898, Mr. Edward S. King for the first time succeeded in satisfactorily photographing the occultation of a star. The apparatus used was an improved form of that constructed for photographing the eclipses of Jupiter's satellites, and described in the *Astrophysical Journal*, Vol. I., p. 146. The plate was moved automatically every second by means of an electro-magnet. A motion of about 3·03 cm. was given to the plate whenever the circuit was closed, and of an equal amount when it was opened. Connecting the apparatus with the standard clock, Frodsham 1327, two images alternately faint and bright were obtained every second. As the faint images are three magnitudes fainter than the bright images, the ratio of the durations was about one to sixteen, so that the absolute durations were 0·06s. and 0·94s. It is here assumed that, as the times of exposure were very short, the chemical action was proportional to the time. This assumption is verified by actual measurement.

Considering only the images taken during the minute following 6h. 35m. 0s., the bright images of 26 Arietis, as shown, are equally intense, including that having an exposure lasting from 50·06s. to 51·00s. Since this image appears to be as bright as the others, the light of the star could not have begun to diminish much before the time 51·00s. If the star had disappeared suddenly at 50·9s. the last image would be at least 0·12 of a magnitude fainter than the others, an amount readily measurable. The next image is apparently invisible. Had the disappearance taken place at 51·06s. the image would appear, and would be as bright as the other faint images. A slight darkening of the film is perceptible near the position the next image would have had, with an intensity nearly equal to that of the fainter images. If this were due to the star it would denote that the latter suddenly disappeared at about 51·12s. The absence of the preceding image would indicate a more gradual disappearance. In any case, the time is fixed at



Occultation of 26 Arietis. (Enlarged 10 times.)

51·1s., to within one-tenth of a second. As the clock was 2m. 19·4s. fast, not including armature time, the corresponding Greenwich mean time is 12h. 54m. 26·5s. By using shorter exposures the uncertainty in the time of disappearance can doubtless be greatly reduced, especially in the case of the brighter stars. Since satisfactory images of 26 Arietis, magnitude 6·1, were obtained in 0·06s., it is

probable that occultations of stars as faint as the ninth magnitude can be observed photographically.

Measures were next made of the intensity of the last five images of 26 Arietis, to see if there was any diminution in light due to the absorption of a lunar atmosphere. The distances of these images from the moon's limb were 1·8″, 1·4″, 1·0″, 0·6″, and 0·2″, respectively. The corresponding changes in light expressed in magnitudes as compared with ten more distant images were +0·03, +0·03, —0·02, +0·03, and —0·02. A positive sign denotes that an image was fainter than those at a greater distance from the moon. From this it appears that no diminution in light was perceptible. No correction need be applied to any of the above calculations for the diameter of the star's disc, since, assuming its intrinsic brightness equal to that of the sun, its time of disappearance would be only 0·002s. (*Proc. Amer. Acad.*, XVI., p. 1.

In this connection it is interesting to note that the determination photographically of the position of the moon by means of a star about to be occulted, was one of the subjects investigated by Prof. G. P. Bond forty years ago. He obtained a number of photographs of the moon and α Virginis shortly before the occultation of the latter on June 2nd, 1857.

A VARIABLE BRIGHT HYDROGEN LINE.

The presence of the bright hydrogen line Hβ in the spectrum of the star A. G. C. 9181 was found from the Draper Memorial photographs in 1895, and was announced in the *Astrophysical Journal*, Vol. I., p. 411. From a comparison of photographs of this object taken on different dates Miss A. J. Cannon finds that this line is variable. On October 5th, 1892, it was invisible. On November 28th, 1894, it was about half as bright as the corresponding line in A. G. C. 9198, ω Canis Majoris. On April 27th and 30th, 1895, the line in A. G. C. 9181 was distinctly the brighter of the two, while in January, 1897, it was again invisible. From a large number of photographs of this object taken recently it appears that this line, which was bright in October, 1897, is now, December 27th, invisible.

A NEW SPECTROSCOPIC BINARY.

From an examination of the Draper Memorial photographs Mrs. Fleming finds that the star A. G. C. 20263, β Lupi, is a spectroscopic binary. The period has not yet been determined, but photographs are being taken for this purpose.

Measures of the spectroscopic binaries, μ^1 Scorpii and A. G. C. 10534, show that the relative velocities of the components are approximately 460 km. and 610 km. respectively. The velocities are therefore much greater than in the case of ζ Ursæ Majoris and β Aurigæ. The separation of some of the lines amounts to as much as nine tenth-metres.

PHOTOGRAPHIC SPECTRUM OF THE AURORA.

Various attempts have been made at this observatory to photograph the spectrum of the aurora. In 1886 on several occasions long exposures were given to plates during bright auroras, but no result was obtained. On April 1, 1897, Mr. Edward S. King succeeded in obtaining a photograph in which four bright lines were visible, but uncertainty existed regarding their wave lengths. The exposure was one hundred and forty-seven minutes. During the bright aurora of March 15th, 1898, he obtained a photograph showing two bright lines. The exposure was one hundred and forty-one minutes. The brightest of these lines extends in wave length from about 3892 to 3925, and the wave length of the second is 4285. Assuming the two brighter lines photographed in 1897 to be identical with these, the four lines on that plate have the wave lengths 3862, 3922, 4288, and 4694. The first of these lines is very faint.

The errors of measurement of these lines do not exceed one or two units, but much greater uncertainty exists in the reduction owing to difficulties in comparing them with the lines of the solar spectrum, which was photographed upon the same plate. Probably the two auroras gave different spectra. That in 1897 was taken with a wide slit, but the images of the lines were well defined on the edges and of equal width, so that the line 3922 was probably really narrow and coincident with the edge of greater wave length of the line 3892 to 3925. The spectroscope used was not especially designed for photographing faint surfaces, and it is hoped that better results may be obtained with a new instrument now in course of construction. As is the case with all results announced in these circulars, it is expected that full details will be published later in the annals of the observatory.

Harvard College Observatory. EDWARD C. PICKERING.

Notices of Books.

The Smithsonian Institution, 1846-1896: the History of its First Half-Century. Edited by George Brown Good. (City of Washington.) When James Smithson, in 1826, drew up his will containing this most significant provision, "I bequeath the whole of my property to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men," he laid the foundation of an organization which, for half a century, has been one of the most important agencies in furthering the intellectual development of mankind. The institution is a rallying point for workers in every department of scientific and educational activity, and the chief agency for the free distribution of books, apparatus of research, and of scientific intelligence throughout the world. Its publications, which include some hundreds of volumes, are sent to all the most important libraries in the world, and many of them, it is safe to say, are found on the work-table of every scientific investigator. In view of the present enthusiasm for the idea of the federation of the Anglo-Saxon races, it may not be inopportune to point out that James Smithson was an Englishman who graduated at Oxford in 1786. "The best blood of England flows in my veins," he once wrote; "on my father's side I am a Northumberland, on my mother's I am related to kings." This sumptuous volume contains a complete history of the Institution, and appreciative notices (each by a distinguished man of science) of the various branches of work carried out under its auspices during its existence. Though the plan of the volume is due to the late Dr. Goode, the enormous labour involved in seeing the work through the press has fallen upon Prof. S. P. Langley, the present secretary of the Institution, whose own contributions to science have placed him in the foremost rank among investigators of natural phenomena. The volume is in every way a worthy jubilee memorial; the printing, the plates—in fact, the whole *format*—leave nothing to be desired; and whoever is fortunate enough to obtain a copy may well be gratified at his possession.

Memorials of William Cranch Bond and of his Son George Phillips Bond. By Edward S. Holden. (1897. San Francisco, C. A. Murdock & Co.; New York City, Lenicke Buechner.) It is not given to every man to be a Boswell, but the pity of it is that would-be Boswells do not recognize the fact, and assume the *rôle*. The first part of this book is extremely dull. It consists largely of

autobiographical or biographical sketches of a Bond by himself or by another Bond, and the rest is a repetition of the same, paraphrased by Prof. Holden. The second part is not so dull, consisting as it does of Prof. George Bond's diary during his visits to Europe. Its interest chiefly lies in the comments of a personal nature on contemporary philosophers. We confess to being interested in hearing that he "found M. Plantamour a young man of thirty, and very good looking *for a savant*"; that he noticed "that the most distinguished scientific men are bad, hesitating speakers—except, perhaps, Sir John Herschel." The last part of the book consists of letters from or to the Bonds from other scientists, which are simply the short epistles that one astronomer must write to another in the ordinary course of business. We fail to see why they were inserted, except that they occupy some sixty pages.

A Treatise on Magnetism and Electricity. By Prof. Andrew Gray, LL.D., F.R.S. (London: Macmillan and Co.) 14s. net. Students of physics have been long awaiting the publication of Prof. Gray's treatise on magnetism and electricity, the first volume of which is now before us. The plan adopted is to "regard electric and magnetic forces as existing in a space-pervading medium in which the electric and magnetic energies are stored, and by which they are handed on from one place to another with a finite velocity of propagation." We need hardly say that this modern plan of regarding the subject has, in the hands of Prof. Gray, resulted in a book which no serious student of physics can afford to neglect. Though an elementary acquaintance with electric phenomena and apparatus is assumed, the reader possesed of a fair knowledge of the calculus will have no difficulty in intelligently following the subject as it is here presented. As stated in the words of Bacon, quoted upon the title page: "All true and fruitful natural philosophy hath a double scale or ladder, an ascendant and descendant, ascending from experiments to the invention of causes and descending from causes to the invention of new experiments." Prof. Gray is concerned with both these processes; and by showing how, first, electrical phenomena can be satisfactorily explained by action in a medium, he is able to also indicate the consequences to which they lead. This treatment is the natural outcome of the pioneer work of Maxwell, who, following the ascendant ladder, elaborated a mathematical theory of electricity which was not only retrospective but prophetic. The volume, of nearly five hundred pages, includes an account of the ordinary facts of magnetism viewed from a theoretical standpoint, a discussion of electrostatics and electric currents, of electro-magnetism, and of the electro-magnetic theory of light. It will undoubtedly occupy a prominent place as a book of reference in every well-equipped library, and will be read wherever the modern aspects of magnetism and electricity are studied.

Memory and its Cultivation. By F. W. Edridge-Green, M.D., F.R.C.S. (Kegan Paul, Trench, Trübner, & Co.) The author of this addition to the "International Scientific Series" claims that the facts he has discovered enable him to learn a subject in about a fifth of the time that it previously took him. With such a tempting allurement, one sets about the task of reading the manual with no little avidity. Unfortunately, however, it is difficult to maintain this preliminary enthusiasm. Though a few of the instances given to exemplify the statements made are interesting reading, we very much doubt whether the volume will find many appreciative readers. The idea of using a physiological basis for the analysis of memory is good, but it needs more careful treatment than it receives in the present book. Physiologists and psychologists will be content to differ from Dr. Edridge-Green's view, that "memory is a definite faculty, and has its seat in the basal ganglia of the brain, separate from, but associated with, all the other faculties of the mind" (page 3). As for the author's elaborate scheme of thirty-seven faculties, it would perhaps be kindest to limit ourselves to the statement that scientific men consider them fantastical and that the general reader will find them misleading. Whoever purchases the book with the idea of improving a bad memory will be disappointed; and few people will be deeply interested in the views which the author has taken the pains to expound.

Ambroise Paré and his Times. By Stephen Paget. (G. P. Putnam.) This is a very attractive volume, beautifully printed and well illustrated. As most of our readers will know, Paré was contemporary with a number of distinguished men whose names are familiar to everyone. We need only mention Shakespeare and Rabelais, Calvin and Knox, to enable Paré's place in history to be located. He was born three years before the battle of Flodden Field, and died (after an eventful life of eighty years) a year and four months after the destruction of the Armada. The volume, upon which we cordially congratulate Mr. Paget, is well worth reading. It is brimful of interesting matter, and though it is but natural that the "Journeys in Diverse Places" from Paré's own pen should attract most attention, yet Mr. Paget's work is well able to sustain the reader's interest throughout. To medical students and practising surgeons this biographical sketch should be particularly readable. How many of them would be content to do as Paré did at Turin? This is what he says in the "Journey to Turin," 1537: "I found a surgeon famed above all others for his treatment of gunshot wounds, into whose favour I found means to insinuate myself, to have the recipe of his 'balm,' as he called it, wherewith he dressed gunshot wounds. And he made me pay my court to him for two years before I could possibly draw the recipe from him. In the end, thanks to my gifts and presents, he gave it to me." (Page 35.) Knowledge is more easily gained nowadays and is less highly prized.

SHORT NOTICES.

The Centuries. Second Edition. (Newman & Co.) 5s. 6d. post free. Intended to supply a skeleton conspectus of general history, and to serve at the same time as a note-book for the reception of additional memoranda, this book is designed as a study-table companion for readers in biography or history. It forms a chronological synopsis of history on the "space-for-time" method, a page being allowed for every century, which is divided into ten-year periods, and each event is inserted as nearly as practicable in its proper position. The year "*one*," it is edifying to note, in this work is placed ten thousand years before the Christian era!

Modern Architecture. By H. Heathcote Statham. (Chapman & Hall.) Illustrated. Mr. Statham has treated a very intricate subject in a lucid style. At the present day bridges, theatres, and many buildings of a commercial kind are too frequently constructed rapidly and without any serious effort at artistic effect. Believing that the sight of artistic buildings will produce ennobling results on the rising generation, the author in his book—which is comprehensive, and embraces street, public, and domestic architecture—exerts himself to arouse greater enthusiasm for decorative effect in those who have never been able to raise themselves above the purely utilitarian.

Elementary Botany. By Percy Groom, M.A., F.L.S. (George Bell & Sons.) Illustrated. 3s. 6d. "Though by no means a 'cram book' for elementary examinations, a thorough knowledge of the contents of this book will enable a candidate to pass with distinction." This is what the author says in his preface. Mr. Groom insists on the free use of the simple microscope in commencing the study of botany, and in these lessons the compound microscope is deemed unnecessary.

XUM

A somewhat novel departure in the work consists in the study of vegetable physiology prior to a knowledge of the histology of plants; a plan which, we think, is open to criticism, inasmuch as it is fairly comparable to entering upon the study of a steam engine before having mastered the principles involved in the simple mechanical powers.

The Building of the Intellect. By Douglas M. Gane. (Elliot Stock.) 5s. The author of this book endeavours to present to the reader some of the leading views pertaining to man's education in all its aspects. He says: "Education being now regarded as a question of such vital importance, and opinions differing so widely as to its method, character, and scope, a summary of the views of those best qualified as guides and teachers cannot fail to arrive at something like unanimity of opinion." The volume, which is happily hung together, consists mainly of extracts from recognized authorities, the author modestly preferring this method rather than the bolder plan of clothing their opinions in his own words.

We have received from Messrs. Darlington & Co., of Llangollen, a parcel of their excellent handbooks for tourists, including their new "Guide to London," by Mrs. E. T. Cook. This latter is probably the most complete handbook to London ever issued. It is fully illustrated with maps, plans, and views of the great city; contains a most informing index; and is both well written and admirably planned. Finally, Mr. E. T. Cook has himself contributed the chapters on the British Museum, the National Gallery, and the National Portrait Gallery.

BOOKS RECEIVED.

The Flora of Perthshire. By Francis Buchanan W. White. (Blackwood.) 7s. 6d. net.

The Cid Ballads. By the late James Young Gibson. Edited by Margaret Dunlop Gibson. (Kegan Paul.) Portrait. 12s.

The First Philosophers of Greece. By Arthur Fairbanks. (Kegan Paul.)

The Epic of Sounds. An Interpretation of Wagner's "Niebelungen Ring." New Edition. (Novello.) Illustrated. 3s. 6d.

Elementary General Science. By A. T. Simmons and L. M. Jones. (Macmillan.) Illustrated. 3s. 6d.

First Stage Magnetism and Electricity. By R. H. Jude. (Clive.) Illustrated. 2s.

Return—Technical Education—Application of Funds by Local Authorities. (Spottiswoode.) 1s. 6d.

Text-Book of Physical Chemistry. By Clarence L. Speyers. (Spon.)

Electro-Physiology. By W. Biedermann. Translated by Francis A. Welby. Vol. II. (Macmillan.) Illustrated. 17s. net.

The Story of Photography. By Alfred T. Story. (Newnes.) Illustrated. 1s.

Responsible or Irresponsible? Criminal or Mentally Diseased? By Henry Smith, M.D. (Watts & Co.) 1s.

Scientific Method in Biology. By Dr. Elizabeth Blackwell. (Elliot Stock.)

Industrial Electricity. Edited by A. G. Elliott. (Whittaker.) Illustrated. 2s. 6d.

The Process Year-Book for 1898. (Penrose.) Illustrated.

London in the Time of the Diamond Jubilee. By Emily Constance Cook. (Darlington & Co., Llangollen.) Illustrated.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

"THE MASSES AND DISTANCES OF THE BINARY STARS."

To the Editors of KNOWLEDGE.

SIRS,—Referring to Mr. Gore's paper on the "Masses and Distances of the Binary Stars." In his paper of December, 1894, he used −25·5 as the stellar magnitude of the sun. In his present paper he assumes −27, but assigns no reason for the change. Will he explain?

The word "brightness" seems to be used by Mr. Gore in a sense in which I think it implies something he does not intend. I may be wrong, but I think he means "quantity of light." We cannot tell how "bright" a star is when we only know its *mass* and distance. We could if we knew its *surface* and distance. Assuming that Mr. Gore is right in his data for γ Leonis, for instance, and that its mass equals that of the sun, while it emits two hundred and sixty-three times as much light as the sun: this may be accounted for either on the supposition that it is two hundred and sixty-three times as bright, or a little over sixteen times the diameter of the sun, or evidently any compensatory variations in the two data. Of course Mr. Gore knows all this, but the double use of the word "brightness" gives trouble in reading his papers, and leads him into such a sentence as, "Hence we see that Sirius is nearly ten times brighter than it would be had it . . . the same brightness of surface as the sun has." It cannot be *brighter* if of the *same brightness*. When I light a second candle I get twice the surface and twice the light of the one, but neither candle is *brighter* than the one first lighted.

EDWIN HOLMES.

MERCURY.

To the Editors of KNOWLEDGE.

SIRS,—Mr. C. B. Holmes's detection of Mercury on April 12th, seven minutes after sunset, would certainly establish "a record for a London view" if the object he saw can be unquestionably identified as Mercury. The planet Venus was, however, in the very same region of sky, and not more than about six and a half degrees distant, in a south-westerly direction, from Mercury. If Mr. Holmes really observed the latter, then he must naturally have also seen the far more brilliant object Venus.

Your correspondent's observation is such a remarkable one that I am induced to suggest that Venus may possibly have been mistaken for Mercury. On consulting my note-books, I find that though I have obtained at least ninety-four naked-eye observations of Mercury, I have never been able, under the most favourable conditions, to distinguish the planet within half an hour of sunset.

Bristol, 1898, April 29th. W. F. DENNING.

"DESERTS AND THEIR INHABITANTS."

To the Editors of KNOWLEDGE.

SIRS,—Mr. Lydekker, in your last issue (p. 101), ridicules "the idea that flints and other stones grow." As one with "more or less intimate acquaintanceship with science" I think his illustration unfortunate and misleading, for if segregation means growth—which I assume it does—then, startling as it may appear, stones do "grow."

G. ABBOTT, M.R.C.S.

[Your correspondent fails to realize the difference between *rocks* and *stones*. Rocks, during their formation, such as the sand and shingle of our beaches, may, in a sense, be said to grow; but the stones composing such shingle grow only in one way—that is, less. Similarly, congretions and segregations, such as flints, grow while in course of formation in their native rock, but, when denuded and reduced to the condition of stones, only alter in size by diminution. I must decline further discussion on the matter.—R. L.]

Science Notes.

A LITTLE pamphlet giving "Local Particulars of the Total Eclipse of the Sun on May 27th, 1900," has just been issued from the *Nautical Almanac* office. In America, the path of the moon's shadow reaches from New Orleans in Louisiana to Norfolk in Virginia; and in the Eastern Hemisphere, from Oporto in Spain to Algiers in Northern Africa.

Raoul Pictet, of Geneva, and Louis Paul Cailletet, of Paris, received the Davy medal of the Royal Society, in 1878, for their researches on the liquefaction of gases—including hydrogen, which, however, was scarcely more than a mere fog in the glass tube. Prof. Dewar has during the past month performed the unprecedented feat of liquefying hydrogen to the amount of half a wineglassful in five minutes. The boiling point of hydrogen is −240° C., and the density of the liquid, there is reason to believe, is about 0·6, water being taken as the unit.

Prof. Boyd Dawkins, in a letter to the "Times" dated 7th May, protests against the removal of the Jermyn Street Museum and Library to South Kensington, recommended in an interim report of the Select Committee. He says: "It would be worse than a mistake to uproot it and make it a mere unit in the fortuitous concourse of atoms known as the Science and Art Museum at South Kensington. . . . If technical education is to be encouraged our museums must be multiplied and made more accessible to the many, instead of being diminished or concentrated in a suburb where they can only be a luxury of the few."

On Monday, the 7th May, the Council of the Royal Geographical Society awarded one of the two medals to Dr. Sven Hedin for his work in Central Asia, and especially for his survey of the glaciers of Mustagata. The Doctor was the first explorer to cross the Takla-Makan desert, and has done much good work in further advancing our knowledge of the physical geography of the Lob region. The other medal was awarded to Lieut. E. A. Peary, for his explorations in Northern Greenland, begun twelve years ago, and especially for his sledge journey across the Greenland ice, and the discovery of its northern termination.

We understand that the valuable collection of meteorites formed by Mr. James R. Gregory is to be disposed of as a whole. As the collection includes about five hundred specimens, rich in fine examples of the earlier "falls," and has occupied nearly forty years in the compilation, it might be a useful acquisition for some museum.

The Royal Photographic Society's Exhibition at the Crystal Palace was a great success, and almost all branches of photography were well represented. The most striking feature of the exhibition was the degree of perfection which photography has attained as an art, many beautiful enlargements being "as good as pictures." Photography, as applied to science, was in quality excellent, but one would like rather more of it. A few choice astronomical subjects (the eclipse being well shown), also a fair proportion of photomicrographs and radiographs, deserved careful study. There were, too, some very successful flash-light photographs in coal mines, and a marvellous panoramic view from a balloon taken by means of the telephoto lens.

ORNITHOLOGICAL NOTES.—Owing to the absence from England of Mr. Harry Witherby, these have to stand over until next month.

AFRICA AND ITS ANIMALS.

By R. LYDEKKER, B.A., F.R.S.

IF we take a map of the world, and, after tracing upon a sheet of thin paper the outline of the British Islands, cut out the tracing and lay it upon India, we shall find that it covers a mere patch of that great area. Repeating the same process with India, and placing the tracing thus obtained on Africa in such a manner that the sharp angle on the tracing formed by Assam overlies the projecting point of Somaliland, which it almost exactly covers, it will be found that the area embraced in the tracing occupies only a small patch in the middle of the eastern side of the Dark Continent. As a matter of fact, the patch thus marked out ends in a blunt point northwardly some distance above Khartum, thence it runs south to the neighbourhood of the Victoria Nyanza, from which district it rapidly narrows to terminate in a sharp point some distance to the southward of Zanzibar. Allowing for some slight overlaps, no less than six Indias can be traced on the map of Africa; and as these leave between them and on their margins considerable spaces of the country still uncovered, it would be but a moderate estimate that Africa includes at least seven times the area of British India. Some idea, especially to those familiar with our vast Indian dominions, may in this manner be most readily gained of the huge extent of the African continent.

Having made these comparisons of the actual size of the three areas under consideration, I must ask my readers to regard them for a moment from another point of view. Everyone familiar with the birds and mammals of the British Isles is aware that, even excluding Ireland, the same species are not found over the whole area. The Scottish hare, for instance, is specifically distinct from the ordinary English kind, while the red grouse is unknown in the southern and eastern counties of England, and the ptarmigan is confined to the colder districts of Scotland. There are accordingly indications that even such a small area as the British Isles contains local assemblages of animals, or faunas, differing more or less markedly from those of other districts.

Turning to India, we find such local faunas—as might be expected from its larger area—more distinctly defined, and more markedly different from one another. One great fauna occupies the southern slopes of the Himalaya from the base to about the upper limit of trees; this fauna, which includes many peculiar types unknown elsewhere, being designated the Himalayan. The second, or typical Indian fauna, occupies the whole of India from the foot of the Himalaya to Cape Comorin, exclusive of the Malabar coast, but inclusive of the north of Ceylon. The third, or Malabar fauna, occupies the Malabar coast and some of the neighbouring hills, together with the south of Ceylon; the animals of these districts being very different from those of the rest of India. The fourth, or Burmese fauna, embraces only the province of Assam, in what we commonly term India; and many of its animals, again, although of the general Oriental type, are very different from those of the other districts. But even such divisions by no means give the full extent of the local differences between the animals of the whole area. In the second or typical area, for example, the creatures inhabiting the open districts of the Punjab and the North-West Provinces display remarkable differences from those dwelling in the forests of Southern India (the home of the strange loris); while the dwellers in the jungly tract of the south-western districts of Bengal are equally distinct from those of either of the other areas.

Seeing, then, that while slight differences are observable in the local faunas of such a small area as the British Islands, and that much more important ones characterize the different zoological provinces of the vastly larger extent of country forming British India, it is but natural to suppose that distinctions of still higher value would be characteristic of different parts of Africa, accordingly as they differ from one another in climate, and consequently in vegetable productions.

As a matter of fact such differences do occur to a most

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marked degree; but when the vast superiority in size of Africa over India is taken into consideration, the marvel is that the fauna of the greater part of that area is not more dissimilar than it is, and that it has been found possible to include the more typical portion of the continent in one great zoological region or province.

But the reader will naturally inquire what is meant by calling one portion of a continent more typical than the rest. As has been pointed out in an earlier article in this journal,* Northern Africa has, so far as its animals are concerned, been cut off from the districts lying south of the Tropic of Cancer by the great barrier formed by the Sahara; and as the animals of the districts to the north of that desert are for the most part of a European type, while Southern Europe and Northern Africa were evidently joined by land at no very distant epoch of the earth's history, the districts north of the Sahara are for zoological purposes regarded as part of Europe and Asia. Typical, or Ethiopian Africa, as it is more generally termed, includes, therefore, only such portion of the continent as lies to the south of the northern tropic.

But the critical reader may perhaps here be led to remark that some at least of the animals of Northern Africa are common to the South; the lion, whose range extends from Algeria to the Cape, affording a case in point. To this it may be replied that, popular prejudice notwithstanding, the lion cannot in any sense be looked upon as a characteristic African animal. Although year by year growing rarer, it to this day still lingers on in certain parts of Western India, while it is likewise found in Persia and Mesopotamia, and within the historic period was common in South-Eastern Europe. At a still earlier epoch, as attested by its fossilized remains, it was an inhabitant of our own island. It may, therefore, to a certain degree be regarded as a cosmopolitan animal, which may have obtained entrance into Africa by more than one route. In a minor degree the same may be said of the hippopotamus, which was formerly found in the lower reaches of the Nile, and at a much earlier epoch in many parts of Europe, inclusive of Britain. Being an aquatic animal, it can avail itself of routes of communication which are closed to purely terrestrial creatures.

Of the fauna of typical Africa, as a whole, some of the most striking features are of a negative nature; that is to say, certain groups which are widely spread in most other districts of the Old World are conspicuous by their absence. This deficiency is most marked in the case of bears and deer, neither of which are represented throughout the whole of this vast expanse of country. Pigs allied to the wild swine of Europe and India are likewise lacking; their place being taken by the bush-pigs and the hideous wart-hogs, both of which are among the most characteristic of African animals. Except for a couple of species of ibex in the hills of the north-east, sheep and goats are likewise unknown in a wild state. Among other absentees in the fauna, special mention may be made of marmots, and their near allies the susliks, as well as of voles, beavers, and moles.

Of the mammals (and space permits of scarcely any reference to other groups) which may be regarded as characteristic of typical Africa as a whole, the following, in addition to the bush-pigs and wart-hogs already mentioned, are some of the most important. Among the monkeys the most widely distributed are the hideous baboons (*Papio*), now restricted to Africa and Arabia, the southern portion of the latter country being included in the same great zoological province. The guenons (*Cercopithecus*), species of which are the monkeys commonly led about by organ-grinders, have also a wide distribution on the continent, although of course more abundant in the forest regions than elsewhere; and the guerezas (*Colobus*), one of which was described some months ago in KNOWLEDGE,* have also a considerable range. In a totally different group, the curious little jumping shrews (*Macroscelides*) form a peculiarly characteristic family of African mammals belonging to the insectivorous order. There are also many peculiar genera of mungooses, but as most of these have a more or less local distribution they can scarcely be considered characteristic of the continent as a whole; still, they are quite different from those found elsewhere. A very curious carnivorous mammal known as the aard-wolf (*Proteles*), strikingly like a small striped hyæna, is not the least peculiar among the animals of Africa, where it has a comparatively wide range. The hunting dog (*Lycaon*), which presents a considerable resemblance to the spotted hyæna, is an equally remarkable representative of the dog family. Although formerly found in Europe, the spotted hyæna itself is now exclusively African.

Passing by the rodents, or gnawing mammals, as being less familiar to non-zoological readers, we have the two species of hippopotami absolutely confined to Africa at the present day; we are all familiar with the common species in the "Zoo," but the small West African kind, which has more the habits of a pig, is much less commonly known.

The stately giraffes are solely African, but appear to be mainly confined to the more open districts. The herds of antelopes, for the most part belonging to generic types unknown elsewhere, with the exception of a few in Arabia, form one of the most distinctive features of African life. Many of them, like the strange gnus and the graceful gemsbok group, are confined to the open districts of the south and east; but others, such as the bush-bucks and the harnessed antelopes, have representatives in the forest districts of the west. Both species of African rhinoceros are quite different from their Oriental relatives, but only one of these, the common species, has a wide distribution in the country. Zebras, and the now extinct quagga, are familiar and striking African animals, although they are confined to the open plains and mountains. On the other hand, the African elephant, which differs so widely in the structure of its teeth from its Asiatic relative, has a much more extensive distribution, and may therefore be classed among the most characteristic of Ethiopian animals. Even more peculiar are the little hyraces (*Procavia*), the miscalled coneys of our version of the Bible, which form a family absolutely peculiar to Africa, Arabia, and Syria; some of the species dwelling among rocks, while others are active climbers, and frequent the forest districts. But perhaps the strangest mammal that may be regarded as characteristic of Africa as a whole is the aard-vark (*Orycteropus*), commonly known to the colonists as the ant-pig. It is a strangely isolated creature, having at the present day no near relations, either poor or otherwise.

The African buffaloes, with their several races or species, also belong to a type quite peculiar to the continent. To a great extent the ostrich is characteristic of Africa and Arabia, although there is evidence to show that it formerly enjoyed a considerable range in parts of Asia.

The above are only a few of the more striking instances showing how different are the animals of Africa as a whole from those of the rest of the world. Many others might be added, but they would only weary my readers. Of course, there are many groups, like the cats, common to other

* "Deserts and their Inhabitants," KNOWLEDGE, May, p. 101.

* June, 1897, p. 130.

countries, the lion and the leopard being found alike in Africa and India; but such do not detract from the peculiarity of the African fauna as a whole. And here it may be mentioned that a large proportion of the types now peculiar to the Dark Continent appear to have come from India or some adjacent country, fossil remains of baboons, giraffes, hippopotami, ostriches, antelopes of an African type, and not improbably zebras, having been discovered in the Tertiary deposits of India.

But if the animals of Africa as a whole stand out in marked contrast to those of the rest of the world, much more is this the case when those characteristic of certain districts of that huge continent are alone taken into consideration. And most especially is this so with the inhabitants of the great tropical forest districts extending from the west coast far into the interior of the continent—reaching, in fact, the watershed between the basins of the Congo and the Nile in the neighbourhood of Wadelai. Since a large number of the peculiar animals of this district are more or less exclusively confined to the west coast, extending from Sierra Leone to the Congo, the area is appropriately termed the West African sub-region. It is here alone that we find the gorilla and the chimpanzee, the former being restricted to the neighbourhood of the coast, whereas the latter ranges far into the heart of the continent. And this district is likewise the exclusive home of the pretty little mangabys, or monkeys with white eyelids (*Cercocebus*). The galagos, which are near relatives of some of the lemurs of Madagascar, extend throughout the forest region; but the even more curious pottos, or thumbless lemurs, are confined to the west coast. Huge and forbidding fox-bats, some of them with remarkable tufts of long white hairs on the shoulders, are likewise restricted to this portion of the tract, as is the insectivorous otter, or *Potamogale*, first discovered during the travels of Du Chaillu. The equatorial forest tract is also the sole habitat of the African flying squirrels, distinguished from the very different flying squirrels of Asia by the presence of a number of scales on the under surface of the tail. Most of these belong to the genus *Anomalurus*, but the smallest of all forms a genus (*Idiurus*) by itself, and will be familiar to readers of this journal by a life-sized portrait published some years ago. Dormice of peculiar types and tree mice are also very characteristic of this tract. But far more generally interesting are the pigmy hippopotamus of Liberia and the water chevrotain (*Dorcatherium*) of the west coast, an ally of the true chevrotains of India and the Malay countries. So far, indeed, as the equatorial forest tract fauna has any representative in other parts of the world, it is to the Malay peninsula and islands that the resemblance is closest. It is there alone that the other large manlike ape—the orang—dwells; and there is a group of brush-tailed porcupines common to these two districts, and unknown elsewhere throughout the wide world. Both faunas, however, in all probability trace their descent from the animals inhabiting Europe during the Pliocene and Miocene epochs, among which was an extinct species of water chevrotain.

The other great sub-regions include the open grazing grounds and mountains of South and East Africa, the fauna of which is quite different from that of the equatorial forest tract. Minor divisions may also be recognized in this area, the Cape having many animals not found further north. Among the latter are the so-called white rhinoceros, the pretty little meerkat (*Suricata*), the long-eared fox (*Otocyon*), and the Cape sand mole (*Bathyergus*), which, by the way, has nothing to do with the true moles, being a member of the rodent order. This tract as a whole may be termed the east-central sub-region; and to it belong the great hosts of antelopes, the zebras, and the aard-wolf and hunting dog. Very characteristic of the southern and eastern parts of this tract are the beautiful golden moles (*Chryschloris*), unique among mammals for the lovely play of iridescent colours on the fur, and which have comparatively nothing in common with the moles of Europe and Asia. To the northward, in Abyssinia, this tract is the home of another very remarkable animal, the great gelada baboon (*Theropithecus*), easily recognized by the lionlike mantle of long hair on the fore quarters, whose nearest relatives are the ordinary baboons of Africa.

Whether Somaliland should be included in this area, or should have a division to itself, may admit of argument; but at any rate it has many peculiar animals, among which are a number of antelopes, some of which have but recently been made known to science.

Lastly we have the Saharan sub-region, which contains a comparatively limited fauna, passing by almost insensible degrees into that of Northern Africa.

In some respects, especially in its galagos, the fauna of Africa presents a certain resemblance to that of Madagascar; but the connection between that island and the mainland was evidently very remote, and must have taken place before the great incursion of antelopes, zebras, rhinoceroses, monkeys, elephants, etc., from the north, as none of these are found in the island. Madagascar, therefore, is best regarded as forming a zoological province by itself.

Within the limits of a single article it is manifestly impossible to give anything like an adequate sketch of the fauna of such an extensive area, but such points as have been noticed serve to show in some faint degree its richness in peculiar forms of animal life.

THE VINEGAR FLY AND THE VINEGAR MITE.

By C. AINSWORTH MITCHELL, B.A., F.I.C.

THE vinegar eel, of which a description appeared in a recent number of KNOWLEDGE (page 53), is not the only creature with a marked partiality for vinegar, for two other animals have become so associated with its manufacture that they are known as the vinegar fly and the vinegar mite.

The vinegar fly (*Drosophila funebris*) is of very common occurrence, and may be found in any vinegar works during the hotter months of the year. It is about a tenth of an inch in length, and is characterized by large red eyes, red thorax, and red legs. The abdomen is black with yellow stripes, and the wings are somewhat longer than the body. According to Brannt the larva is white, has twelve segments to its body, and four wart-like structures on its back, two of these being yellow. After eight days it is transformed into a yellow chrysalis.

Vinegar makers are not in the habit of paying much attention to the presence of the vinegar fly, since, as far as is known, it does not in any way affect the manufacture; and it is readily prevented from becoming a nuisance by keeping the works thoroughly clean and not allowing any spilt vinegar to lie about on the ground.

The vinegar mite, unlike the fly, must be regarded as a distinct enemy to the acetic bacteria, though not, perhaps, to the same extent as the vinegar eel. When once it has obtained a footing within an acetifier it multiplies with amazing rapidity, interferes with the oxidation process, and is not easily exterminated. Dr. Bersch describes the state of an Italian factory about which he was consulted in 1881. Every drop of vinegar produced contained one or more of these mites, which were present in myriads

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on every part of the acetifiers, and which finally had brought the manufacture to a complete standstill—the manufacturer being unable to account for their presence beyond stating that they were derived from the soil beneath his apparatus.

In its simplest form an acetifier consists of a large vat with a perforated false bottom. The space above this is filled with shavings or other porous material on which the bacteria settle, and the alcoholic liquid is pumped over and over through the shavings until the whole of the alcohol has been converted into acetic acid. The necessary air is admitted through holes made in the side of the vat, whilst smaller holes at the top allow the waste air to escape. Many modifications of this apparatus are in use, in which means are taken to exactly regulate the air supply and the temperature; but it is in this simple form, as first invented by Schützenbach in 1823, that most of the acetifiers in England and Germany are constructed. Prior to Schützenbach's invention, which is still known as the "quick vinegar process," vinegar was made by placing the alcoholic liquid with a little vinegar containing the bacteria in barrels, which were turned and aërated from day to day by workmen. It is through the holes for aërating the acetifier that the vinegar mite finds its way into the interior, and attempts have been made to prevent this by placing birdlime round the outside of the holes, whilst in some of the more recent patents fine wire gauze is employed for the same purpose. At first the acetic bacteria do not appear to be much affected by the presence of the mites, but as these increase and then die off and fall to the bottom their dead bodies begin to putrefy, and the putrefaction bacteria or their products sooner or later have an injurious effect, and if not removed will eventually completely master the acetic bacteria.

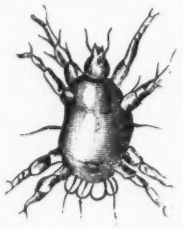


FIG. 1.—From the under side. × 120 diameters. After Bersch.

The vinegar in which the mites have thus gained the upper hand has a peculiar yellowish shade, and contains what appear to the naked eye to be a large number of white specks. When examined under the microscope these have the appearance shown in Figs. 1 and 2.

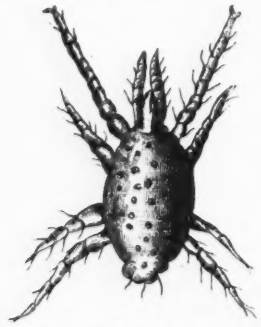


FIG. 2.—× 120 diameters. After Bersch.

These two forms, apparently those of the male and female, are always found, many of the individuals being only one quarter or one half of the size of the others. Bersch assigns them to the class of *Sarcoptidæ*, but little appears to be known about their life history.

When once vinegar mites have established themselves within an acetifier they can only be expelled by destroying them simultaneously with the acetic bacteria. For this purpose the vat must be emptied of vinegar as completely as possible, and the interior thoroughly washed with hot water, well fumigated with burning sulphur until all life is destroyed, and then washed again. It is then charged afresh with the alcoholic liquid and a little crude vinegar containing the bacteria, but of course it is some time before the apparatus gets into working condition again.

A CLASSIC LEGACY OF AGRICULTURE.

By JOHN MILLS.

ALL great discoveries are the result of much study, and often arise out of those truths of science which appeared least promising on their first announcement. The time is past when practice can go on in the blind and vain confidence of a shallow empiricism, severed from science like a tree from its roots. Scientific principles are now extensively applied in problems concerned with the improvement of the artificial means employed for increasing the fertility of the soil. During the last sixty years, more especially, the transmuting power of the "philosopher's stone" has been displayed, and many triumphs have been achieved through the painstaking researches of men who, like Sir John Lawes and Sir Henry Gilbert,* are not content to adhere strictly to the rule-of-thumb methods which have been in vogue for untold ages.

Agriculture is both an art and a science. On the scientific side chemistry plays an important part, and is called into request for the investigation of the composition of soils, manures, and of the vegetable and animal substances which it is the aim of agriculture to produce. All the conditions of the life of vegetables, the origin of their elements, and the sources of nourishment, are secrets which can be elicited by the aid of science. Given a barren tract of country, which has been unproductive from generation to generation, the scientific agriculturist will improve the parts by transporting and transposing the different soils. The analysis of the soils will be followed by that of the waters which rise or flow through them, by which means he will discover those proper for irrigation. A knowledge of chemistry teaches us when and in what condition to use lime, and the difference in the properties of marl, peat, dung, mud, ashes, alkali, salt, soap-waste, sea-water, etc., and consequently which to prefer in all varieties of soil—a knowledge which thus imparts a new character to the agriculturist, and renders his employment rational. Environed by an endless variety of processes and results, scientific agriculture is constantly disclosing surprises. The nineteenth century has witnessed developments greater than those of all previous time. It is as true to say now that agriculture is in a state of transition and development as it was a century ago to say it was in a state of inanition and even stagnation. The position of agriculture is now hopeful, for the age is progressive. It is a period of adaptation, of new departures, new energy, and greater economy. Foreign competition is understood and expected. To know what it is provides the means of meeting it.

We purpose in this article to afford a glimpse of the artificial aids to agriculture which Sir John Lawes and Sir Henry Gilbert have for upwards of fifty years practised at the Rothamsted Agricultural Experimental Station—the model of all agricultural stations, and the methods there introduced are everywhere regarded as classical. The researches carried on by these collaborators have elicited information which will ever serve as the foundation of a truly scientific knowledge of the correlation of plant-growth and manurial constituents of the soil, and will be of the utmost value in all discussions of the chemistry of plant life. The immense number of exact data which they have placed at the disposal of chemists is without parallel in the annals of science. As Sir Joseph Hooker has said, in the whole history of science, never have two of its greatest divisions been brought into more profitable cor-

* We are much indebted to both Sir John Lawes, Bart., F.R.S., and Sir Henry Gilbert, F.R.S., for generous assistance in explaining the arrangement of the experimental plots at Rothamsted, the conduct of the laboratory, and in placing records, etc., at our disposal in preparing this article.

relation than chemistry and botany have been in the Rothamsted experiments. The far-seeing intelligence which devised the details affords results which have completely reformed the practice of agriculture, and the carrying on of a single research without interruption during a period of over fifty years is unexampled—a research which has taught those concerned how to estimate the actual mean fertility of the earth's surface, and, in the subordination of permanent pasture to the practical advantage of the farmer, to successfully employ readily available chemistry to modify at pleasure the entire character of the vegetation.

Sir John Lawes, apart from his scientific researches in conjunction with Sir Henry Gilbert, is probably the oldest practical farmer in England, and inherited all the traditions of a long ancestry, so that he may truly be regarded as an adherent to the motto, "Practice with science." The manor house of Rothamsted is situated in the midst of a beautifully wooded park, at Harpenden, near St. Alban's, and the experimental grounds are in the estate adjoining the park. Sir John first commenced operations in 1834, soon after succeeding to his property, first with plants in pots, and afterwards in the fields, using different manuring substances. The researches of De Saussure on vegetation were the chief subject of his study to this end. The most striking results were obtained by the use of neutral phosphate of lime, in bones, bone-ash, and apatite, rendered soluble by means of sulphuric acid. The mixture so obtained answered well for root-crops. In 1843, the date at which the researches commenced in real earnest, and when Dr. (now Sir Henry) Gilbert entered into the work, more systematic field experiments were initiated. These researches relate not only to the growth of cereal and other crops under the most varying conditions, but also to the economic effect of different foods on the development of the animals of the farm. They have embraced, moreover, most important researches concerning the sources from which plants derive their supply of nitrogen.

Following in the wake of the Rothamsted experiments, Germany has worked in the same field, and to-day she can number twenty-five experimental stations, which institute both scientific researches and deal with their adaptation to practice. Germany is indebted to experimental stations for the progress she has made during the last decade, especially in agriculture. Yet while the German stations have been founded by associations of agriculturists and maintained at the public expense, the Rothamsted experiments are due to the activity of two eminent men, and are maintained by private funds; from the commencement they have been entirely disconnected from any external organization, and have been maintained at the sole cost of Sir John Lawes. For the continuance of the investigations after his death, Sir John has made the munificent endowment of one hundred thousand pounds, besides the famous laboratory and certain areas of land, and has nominated some of the most distinguished scientific men of the day to administer the trust.

While it is a fact, affording some cause for self-satisfaction, that the farmers of Great Britain grow a larger produce per acre than the farmers of any other country in the world (the average yield of wheat per acre in 1888 was twenty-eight bushels, while that of the United States, for example, was eleven bushels), it is a noteworthy fact in connexion with these investigations that they have not been of the same benefit to our own nation as they have to some other nations. Thus, while, as in the case of Germany, Government has come to the aid of agricultural research to a praiseworthy extent, enterprise in this country is carried on by private resources, save in the college at Glasnevin, near Dublin, to which a Government grant is allotted; the colleges at Cirencester, Downton, and the Colonial Training College in Suffolk, being self-supporting, and these all draw to a considerable extent upon the researches at Rothamsted for exact information.

The investigations were commenced upon truly orthodox lines, and with truly orthodox views; but as it was not possible to alter the laws of nature, it was soon found that the results brought out did not agree with the views of the recognized authorities of the day. Among other things it soon became woefully apparent how small after all was the available leverage for artificially assisting the processes of nature. Too conspicuous to be mistaken, the weather announced itself as the great factor in producing crops. Every day in the year makes its impression, good or bad, on the final issue, which appears to be something very like the algebraic sum—the positive and negative result of the favourable and unfavourable weather of all the days in the year leaving us the victims of circumstance in spite of all the refinements of science. These investigators also saw clearly the explanation of an experiment which Hale performed more than two hundred years ago. Hale had carefully tended a plant in a pot, and noticed that, although the soil lost very little in weight, the plant increased by an amount tremendously in excess of that lost by what appeared to be the parent soil. Whence came, then, the elements of the plant? The Rothamsted experiments show clearly that about ninety-five per cent. come from the atmosphere, and only some five per cent. from the soil, thus driving home Dumas' saying that "at last analysis we are nothing but condensed air."

Some idea of the magnitude and importance of the researches carried on at Rothamsted may be gleaned from the list of field experiments given in the accompanying table.

CROPS.	Duration.	Area.	Plots.
	Years.	Acres.	
Wheat (various manures) ...	54	11	34 (or 37)
Wheat, alternated with fallow	46	1	2
Wheat (varieties)	15	4–8	about 20
Barley (various manures) ...	46	4¼	29
Oats (various manures)	10*	¾	6
Beans (various manures)	32†	1¼	10
Beans (various manures)	27‡	1	5
Beans, alternated with Wheat ..	28§	1	10
Clover (various manures)... ...	29‖	3	18
Various Leguminous Plants ...	20	3	18
Turnips (various manures) ...	28¶	8	40
Sugar Beet (various manures)...	5	8	41
Mangel-Wurzel (various manures)	22	8	41
Total Root Crops ...	55		
Potatoes (various manures) ...	22	2	10
Rotation (various manures) ...	50	3	12
Permanent Grass (various manures)	42	7	22

* Including one year fallow.
† Including one year Wheat and five years fallow.
‡ Including four years fallow.
§ Including two years fallow.
‖ Clover, twelve times sown (first in 1848), eight yielding crops, but four of these very small, one year Wheat, five years Barley, twelve years fallow.
¶ Including Barley without manure three years (eleventh, twelfth, and thirteenth seasons).

Many of the experiments were commenced without any idea of long continuance, and it was only as the results obtained indicated the importance of such continuance that the plan eventually adopted was gradually developed. It is, however, to long continuance that we owe some of the most interesting and the most valuable results.

The table further shows the area and the number of plots under experiment in each case; and it may be stated that the total area under exact and continuous experiment has been for some years, and is at the present time, about forty acres.

To cultivate and simultaneously investigate scientifically the products of such an extensive series of plots of ground, a staff of workers of no mean order is of course necessary. A number of general assistants, therefore, are engaged to superintend the field experiments—that is, the making of the manures, the measurement of the plots, the application of the manures, and the harvesting of the crops; also the taking of samples, the preparation of them for analysis or preservation, the determination of dry matter, ash, etc., and the keeping of the meteorological records. There is a permanent laboratory staff of two, and sometimes three, chemists, and three or four computers and record-keepers for calculating and tabulating field, feeding, and laboratory results, copying, etc. In addition to a large staff of this kind, the best professional assistance has been called in from time to time. Among these may be mentioned Prof. Frankland, who determined the nitrogen as ammonia, as nitric acid, and as organic nitrogen in many samples both of the rain and of the various drainage waters collected at Rothamsted; Prof. W. J. Russell estimated the sulphuric acid in some of the monthly mixed samples of rain water; the late Dr. Voelcker determined the nitrogen, and likewise the incombustible constituents, in sixty-five samples of the drainage waters; Dr. Richter has made more than eight hundred analyses of the ashes of various products, animal and vegetable, of known history; and the late Dr. Pugh took a prominent part in the experiments to determine whether plants assimilate free nitrogen, and also various collateral points.

Samples of all the experimental crops are taken and brought to the laboratory. Weighed portions of each are partially dried, and preserved for future reference or analysis. Duplicate weighed portions of each are dried at 100° C., the dry matter is determined, and it is then burnt to ash on platinum sheets in cast-iron muffles. The quantities of ash are determined and recorded, and the ashes themselves are preserved for reference or analysis. In a large proportion of the samples the nitrogen is determined; and in some the amount existing as *albuminoids*, *amides*, and *nitric* acid. There is now a collection of more than forty-five thousand bottles of samples of experimentally grown vegetable produce, of animal products, of ashes, or of soils, besides some thousands of samples not in bottles; and the laboratory having become very inconveniently full, a new detached building—a "sample house"—was erected in the autumn of 1888, comprising two large rooms for the storing of specimens and for some processes of preparation, and also a drying room. The general scope and plan of the field experiments has been to grow some of the most important crops of rotation, each separately, year after year for many years in succession on the same land, without manure, with farmyard manure, and with a great variety of chemical manures; the same description of manure being, as a rule, applied year after year on the same plot. Experiments on an actual course of rotation without manure, as well as with different manures, have also been made.

Having thus indicated the scope of the researches at Rothamsted, the resources available, and the disposition of the estate, we shall endeavour in a subsequent article to present some of the remarkable results which have been derived therefrom, and the bearing of the conclusions arrived at on practical agriculture.

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Lewis Swift.—The famous American astronomer, Lewis Swift, well known for his discoveries of nebulæ and comets, furnishes a remarkable example of the retention of brilliant observational capacity to an advanced age. Though the time of his birth dates back to 1820, February 29th, he still discovers numbers of exceedingly faint nebulæ, and occasionally announces a new comet. The most recent of his cometary discoveries was in 1896, April, when he was in the seventy-seventh year of his age! His success has certainly been astonishing. No other comet-finder appears to have effected discoveries at a period so late in life as the veteran of whom we are speaking. Pons was about sixty-six years old, Mechain fifty-five, and Messier sixty-eight, when they sighted their last comets. Let us hope that Swift will yet be spared some years to add to his laurels by the discovery of further objects in the fields where he has already laboured so long and with so much distinction.

Perrine's Comet (March 19th).—This object is still visible, though becoming very faint. At the early part of June its brightness will be only one-fifth that at discovery. An ephemeris was given in the last number of Knowledge.

Periodical Comets.—The comets of Wolf, Encke, and Tempel (1867, II.), are shortly expected to appear, but the circumstances are not favourable. Pons-Winnecke's comet is now exceedingly faint. The following are ephemerides:—

Comet Wolf.

Date.	R.A. h.	m.	s.	Declination. °	′	Distance in millions of miles.
June 3	1	36	19	+18	33·0	204
,, 11	1	59	58	+19	19·0	199
,, 19	2	23	48	+19	51·3	194
,, 27	2	47	43	+20	8·7	190

Comet Encke.

June 1	6	7	12	+20	15·5	82
,, 10	6	46	3	+13	16·6	60
,, 14	7	1	41	+ 9	15·8	51
,, 18	7	18	43	+ 4	24·2	44
,, 22	7	38	59	− 1	38·7	38
,, 26	8	4	46	− 9	16·8	33
,, 30	8	39	19	−18	45·8	28

Comet Pons-Winnecke.

June 3	1	56	4	− 1	7·0	174
,, 11	2	14	26	− 0	12·2	177
,, 15	2	23	3	+ 0	11·4	178
,, 19	2	31	17	+ 0	32·3	179

Comet Tempel (1867, II.).

June 1	11	41	11	+13	50·1	177

Comet Wolf is approaching the earth, but it will not come as near as in 1891, and will probably remain a faint object during the whole of this apparition. It will reach its perihelion on July 4th, though it will continue to become very gradually brighter until the close of October. Comet Encke is rapidly advancing nearer to the earth and its apparent brightness increasing, but its position is not favourable for northern observers, as its motion carries it very quickly southwards. During the month the comet passes from the north-west extremity of Gemini to the south-east border of Monoceros. Tempel's comet

will be close to β Leonis at the beginning of June, but its exact place is doubtful.

M. Legarde has recently published a new determination of the orbit of Tempel's comet of 1871. The comet was observed during an interval of one hundred and nine days, and its orbit appears to be that of a very excentric ellipse, with a periodic time of about two thousand and thirty years.

The April Meteors.—Prof. A. S. Herschel, at Slough, registered the paths of sixty-eight meteors observed on clear nights between April 12th and 24th. The sky was hazy on April 19th, and only one uncertain meteor was seen in a watch of two and a half hours' duration. On April 20th clouds prevailed. Very few, if any, Lyrids were observed, but the meteors recorded indicated a large number of minor showers in Corvus, Libra, Ursa Major, Draco, and the region of Hercules. At Bristol, on April 17th, 18th, 19th, and 22nd, meteors were found to be somewhat rare, and very few Lyrids were noticed. Four of the meteors observed at Bristol were also recorded by Prof. Herschel at Slough, but in two cases the observations do not match very well, as the meteors were very indifferently seen at Bristol. Of the other two, one appeared on April 17th, 10h. 28m. It was a small, very slow moving meteor, with a radiant near the southern horizon. Its heights were from seventy-two to seventy miles over Malmesbury to Evesham, and it traversed a path of about thirty-four miles. The other was seen on April 22nd, 10h. 32m. It was directed from a radiant at 252°+49°, and fell from a height of seventy-two to fifty-two miles from above Alcester to Malvern.

The brighter meteors seen by Prof. Herschel were as under:—

Date.	Time. h.	m.	Mag.	Path. R.A. °	Dec. °		R.A. °	Dec. °	Duration in Seconds.
April 16	10	47	1	290	+52	to	327	+52	2·5
„ 16	11	27	1	92½	+44	„	91	+37	0·4
„ 17	9	38½	1	44	+73	„	61	+60	1·0
„ 19	9	53	1	280	+61	„	286	+55	0·8
„ 23	12	43	1½	158	+30	„	138	+37	2·2
„ 23	12	48½	1	232½	− 5	„	231	+ 1	0·4

Mr. W. E. Besley, of Westminster, watched the sky on April 21st and 22nd during an aggregate period of three and a quarter hours, and recorded twenty meteors, of which twelve were Lyrids. The principal radiant appeared to be very well defined at the usual position, viz., 273°+33°.

If observers at other places noted any of these objects the data would be valuable as affording the materials for computing their real heights in the atmosphere.

FIREBALL OF APRIL 5TH.—Mr. G. N. Stretton's description of this object, as observed at Fulham (KNOWLEDGE, May, p. 114), agrees remarkably well with the radiant point at 121°−1°. As seen by your correspondent, the meteor must have ascended in a perfectly vertical course; but if it actually reached the zenith, as he remarks, then the place I gave for the disappearance must be shifted some miles to the north-east, and the height at disappearance must have been a little less than that stated. But in discussing and endeavouring to harmonize materials of this character, one has to adopt the path which best satisfies the majority of the observations. Mr. Stretton's position was evidently very near the point of the meteor's disappearance. The fact that at Bournemouth it fell vertically downwards in north-east, while at Fulham it ascended straight up to the zenith from south-west, affords the clearest proof that the direction of flight of the meteor was on a line joining those two places, and that it successively passed over Bournemouth, Southampton, Alton, and Aldershot, as stated in my paper in your May Number.

THE FACE OF THE SKY FOR JUNE.

By HERBERT SADLER, F.R.A.S.

GROUPS of, and small detached, spots are still to be detected on the solar surface.

Mercury is, theoretically speaking, a morning star, but cannot be conveniently observed for any practical purpose by the amateur during the month, owing to his proximity to the Sun. He is in superior conjunction with that luminary on the **30th**.

Venus is an evening star, and is conveniently situated for observation. On the **1st** she sets at 10h. 17m. P.M., with a northern declination of 24° 42′ at noon, and an apparent diameter of 11½″. On the **11th** she sets at 10h. 26m. P.M., with a northern declination at noon of 23° 42′, and an apparent diameter of 12″. On the **18th** she sets at 10h. 24m. P.M., with a northern declination at noon of 22° 19′, and an apparent diameter of 12½″. On the **25th** she sets at 10h. 18m. P.M., with a northern declination of 20° 27′ at noon, and an apparent diameter of 12½″. On the **30th** she sets at 10h. 15m. P.M., with a northern declination at noon of 18° 51′, and an apparent diameter of 13″. During the month she describes a direct path through a great part of Gemini into Cancer.

Mars is practically invisible.

Jupiter is an evening star, and is still well placed for observation. On the **1st** he rises at 1h. 16m. P.M., with a northern declination of 1° 9′ at noon, and an apparent equatorial diameter of 40½″. On the **11th** he rises at 0h. 35m. P.M., with a northern declination at noon of 1°, and an apparent diameter of 39½″. On the **18th** he rises at 0h. 10m. P.M., with a northern declination of 0° 49′, and an apparent diameter of 38½″. On the **30th** he rises at 11h. 25m. A.M., with a northern declination of 0° 24′, and an apparent diameter of 37½″. During the month he describes a very short path in Virgo.

Our remarks last month about the futility of attempting to observe either Saturn or Uranus in these latitudes apply with equal force to the present month. Neptune is invisible.

There are no very well marked showers of shooting stars in June.

The Moon is full at 2h. 11m. P.M. on the **4th**; enters her last quarter at 6h. 4m. P.M. on the **11th**; is new at 4h. 19m. A.M. on the **19th**; and enters her first quarter at 4h. 54m. A.M. on the **27th**.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solution of May Problems.

(By P. G. L. F.)

No. 1.

1. Q to B5, and mates next move.

No. 2.

Key-move.—1. Q to B3.

If 1. . . . K moves, 2. Q to K2ch, etc.

1. . . . Anything else, 2. Q to Qsq, etc.

[There is a near "try" by Q to Qsq at once.]

CORRECT SOLUTIONS of both problems received from Alpha, K. W., Capt. G. A. Forde, W. F. Denning, E. W. Brook, W. de P. Crousaz, H. S. Brandreth.

Of No. 1 only from G. G. Beazley, W. Clugston, J. M'Robert.

J. Nield (Crompton).—Many thanks; we hope to find space for them this summer.

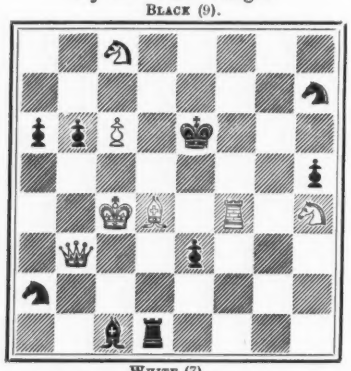
XUM

PROBLEMS.

No. 1.

By A. C. Challenger.

BLACK (9).



WHITE (7).

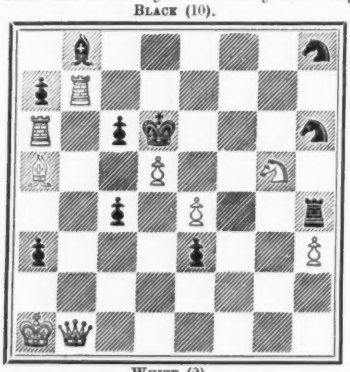
White mates in two moves.

No. 2.

By J. T. Blakemore.

(From the *Birmingham Weekly Mercury*.)

BLACK (10).



WHITE (9).

White mates in three moves.

CHESS INTELLIGENCE.

It is with the greatest regret that we learn the news of the death of the Rev. W. Wayte, for many years honorary treasurer of the St. George's Chess Club, and formerly professor of Greek at London University. Prof. Wayte, who was for twenty-three years a classical master at Eton, was certainly one of the very strongest amateur players in England. His knowledge of the whole theory of the game was profound, the openings being perhaps his especial *forte*. He was a most successful competitor at the annual meetings of the old Counties Chess Association, and was captain of the southern team when the North *v.* South contests were instituted. Prof. Wayte was the editor of an annotated edition of Plato's "Protagoras," and other classical works. His interesting "Chess Reminiscences" appeared in the *British Chess Magazine* (March and April, 1898). It will surprise many who knew him to find that he was in his seventieth year.

We omitted last month to record the result of the Pillsbury-Showalter match. Mr. Showalter did not play nearly so well as last year, and was defeated by seven games to three, with two draws. Mr. D. G. Baird has tied with Mr. Köhler for the championship of the Manhattan Chess Club.

Herr Marco has won the latest Vienna Club tourney, Herr Schlechter being as low as fifth. The international tourney at Vienna begins this month. Considerable dissatisfaction is expressed at the necessity for playing two rounds; so unpopular, in fact, is this condition that the committee have been compelled to extend the time for entries, owing to the paucity of desirable competitors. It is stated that Herr Lasker will be among the abstainers on this account, and possibly, too, Mr. Pillsbury. Messrs. Blackburne, Burn, and Caro will represent England.

Mr. P. F. Blake, the eminent problem composer, has won the level tournament of the Manchester Chess Club. Mr. Lawrence has again won the City of London tournament, although he started badly owing to ill-health. Messrs. L. Seraillier and W. Ward were leading for the greater part of the tournament.

REVIEW.

The Art of Chess. By James Mason. Second Edition. (Horace Cox.) This is an extension of the edition of 1895 from three hundred and eleven to four hundred and twenty pages. The price is increased from five shillings to six shillings net. Apart from a very interesting and suggestive introduction, we find that the section on end games is increased by forty pages; the part dealing with middle-game combinations being practically the same as in the former edition. The section on openings, which Mr. Mason rightly and logically places last, is considerably enlarged, and again the introductory remarks are most useful. Mr. Mason has during the last few years attained the position of the leading English chess author. He is the first Englishman to treat the game as a science to the extent of adopting a scientific method and scientific language in expounding it. Mr. Mason's style is terse and epigrammatic—at times even Carlylean, but, above all things, Masonic. In other words, the book is eminently readable.

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